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BOOZ · ALLEN APPLIED RESEARCH INC.

COMMUNICATIONS RESEARCH AND DEVELOPMENT DATA COLLECTION PROGRAM IN THE REPUBLIC OF VIETNAM

BOOZ·ALLEN APPLIED RESEARCH INC.

WASHINGTON
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Third Semiannual Report
17 July 1966 - 15 January 1967

COMMUNICATIONS RESEARCH AND DEVELOPMENT DATA COLLECTION PROGRAM IN THE REPUBLIC OF VIETNAM

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FOREWORD

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ABSTRACT

This paper summarizes the third six-month period of research by Booz Allen Applied Research Inc., Southeast Asia Operations, in support of the Advanced Research Projects Agency small unit tactical communications project entitled, "Communications Research and Development Data Collection Program in the Republic of Vietnam." It presents an initial analysis of Vietnamese patrol and base communications practices and discusses the on-going program of communications data collection among U.S. and allied units in Vietnam. It describes communications practices in use by some of these units and reports findings to date in the areas of radio wave path physiography, radio frequency, and dialect analyses. It recommends the use of directional-type antennas for tactical very high frequency communications and describes a simple, lightweight antenna concept which could be used by tactical units.

INTRODUCTION

GENERAL

This semiannual technical report is the third in the series which chronicle the project formally entitled, "Communications Research and Development Data Collection Program in the Republic of Vietnam." It reports on the current status of the data collection and on the three ancillary research and analysis tasks which have been assigned. It also reports on the current status of the data collection activity which has been carried on to date among the Vietnamese military and para-military forces and which has recently been extended to the U.S. and allied units in Vietnam.

STATUS

The first year of this project was structured in order to develop a data collection and recording methodology. A system for coding and machine analysis was also developed. Logically, during this period in which the data was being collected, conclusions and observations which might have been made by the study team could not be supported by a sufficient body of data to be valid. However, in this report, preliminary analysis of data which has been gathered over the past year has been carried out by both manual and machine methods. As a result, quantitative data are now available which examine ranges, frequencies, antenna types, and other aspects of small unit communications in Vietnam. At the same time, the data gathered in the basic collection program provide a firm basis on which detailed aspects of the path physiography analysis are being conducted.

This paper also reports on the conclusion of two of the assigned tasks and summarizes the results thereof. The Radio Spectrum Analysis Report has been published and distributed. Data collection and analysis in support of the Dialect Analysis Task has been completed; a detailed report combining results of the field research and the laboratory analysis is now in preparation.

The data collection program has yielded approximately 4, 300 line items of communications data from Vietnamese military and paramilitary forces, and approximately 1, 700 line items from the U.S. and allied forces in Vietnam. It is supplemented by a series of reports on the tactics and communications practices (with emphasis on the latter) of units visited. Samples of these reports on U.S. and allied units are extracted and presented in a classified appendix of this paper. Unclassified comments upon Vietnamese communications practices are included in the next chapter.

FUTURE PLANS

Data collection continues from the Vietnamese forces at a greatly reduced rate, caused by the revectoring of the data collection program to the U.S. and allied forces. Machine analysis of the Vietnamese data continues; correlation with the various aspects of the path physiography analysis will commence within the next month.

The coding and preparation of punch cards of data received from the U.S. and allied forces will continue. When a sufficient quantity of this material has been prepared, analysis in a manner similar to that shown in the next chapter will commence.

The wave path physiography study will continue to build on the Vietnamese data base now established and will, as increasing data become available from the U.S. and allied forces, extend the analysis to this area. The specialized coding task under the path physiography analysis will continue, and as the special cards are prepared on such topics as soils, vegetation and topography, analysis and correlations with other aspects of the communications as recorded, will become a major element of the task.

Field reports from various units visited, particularly among the U.S. and allied units will continue to be prepared. These form an increasingly significant element of the overall data gathering and recording program, providing a detailed background on communications practices and problems.

PATROL COMMUNICATIONS

GENERAL

The patrol communications task is the keystone of the overall study. Its objectives and methodology have been explained in detail in the previous semiannual reports*. The basic element of the data collection program and subsequent analysis is the "line item." Each line item represents one communication attempt between base and patrol.

A good return has been received from the military and paramilitary units of the Republic of Vietnam (RVN): approximately 4,300 line items have been received and coded. Although many of the data sheets and line items were incomplete, each contained sufficient information to be meaningful to at least one or more tasks of the study. For example, even though the physiography or weather items may not have been filled out, the fact that a communication at a certain frequencies had been carried out between two designated coordinate points is partial information which has significance to the path physiography study. In the tables which follow, therefore, a constantly changing datum will be noted. These tables represent analysis of communications from those units which chose to report the information which is being examined.

DATA PROCESSING

Each line item has been coded according to the data sheets shown in Appendix A. This information is presented at this time in order that future users of the coded data gathered in this task will be aware of the nature and depth of the data collection and its accessibility by machine data recovery methods.

Data coding has been carried on in Saigon by a Vietnamese coding clerk who is capable of reading the Vietnamese data direct from the field data sheets, since much of this information is in the Vietnamese language. Preparation of punch cards has been accomplished at the data processing center of the Joint General Staff of the Republic of Vietnam Armed Forces (RVNAF), and by the 27th Data Processing

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*Booz Allen Applied Research Inc., Southeast Asia Operations, Communications Research and Development Data Collection Program in the Republic of Vietnam, first Semiannual Report (July 1965 - January 1966) and second Semiannual Report (January - July 1966) hereinafter referred to as the first Semiannual Report and the second Semiannual Report.

Unit of the Office of the Adjutant General, Military Assistance Command, Vietnam (MAC-V). Additional machine analysis was performed at facilities made available by the U.S. Army Strategic Communications facility, Thailand.

Data processed at this point is that obtained exclusively from Vietnamese military and paramilitary forces. A data collection program has been in process with these units, starting in the Mekong Delta region, since November 1965. The geographic distribution of these data (Figure 1) not only represents the time sequence of the data collection program but also, to a considerable extent, represents a correlation with the tactical level of activity in the military forces of the RVN and the increasing impact of the arrival of U.S. and allied forces in the Republic. For example, in the Mekong Delta region, during the reporting period, U.S. military presence was limited to the traditional advisory and support (primarily helicopter) roles. The primary tactical interface with the Viet Cong were the Vietnamese military and paramilitary forces, namely the Army of the Republic of Vietnam (ARVN) and the Regional and Popular Forces (RF/PF). The approximately 2,000 line items acquired from this region reflect this role. On the other hand, the paucity of reports from the high plateaus region reflects a generally dormant ARVN tactical posture as an increasingly large share of the tactical action was assumed by U.S. units during the reporting period. Data from the coastal lowlands region reflects a reasonable level of Vietnamese tactical activity diluted by heavy infusions of U.S., Australian and Korean units in their series of coastal enclaves. In the terrace region north of Saigon, which includes the "Iron Triangle" and "Zone D", data are from the ARVN III Corps as extensive U.S. operations in that area only commenced during the reporting period. Data from Vietnamese tactical units continues to be received but as the emphasis of the project has been redirected toward data collection from U.S. and allied units, locally termed the FWF or Free World Forces units, the quantity of Vietnamese data being received is dropping sharply.

PRELIMINARY DATA ANALYSIS - VIETNAMESE FORCES

The data presented in the following tables represent a preliminary machine analysis of approximately 4,000 line items of Vietnamese data received and placed on punch cards. Range calculations carried on under the physiography wave path analysis task are presented in the physiographic portion of this report.

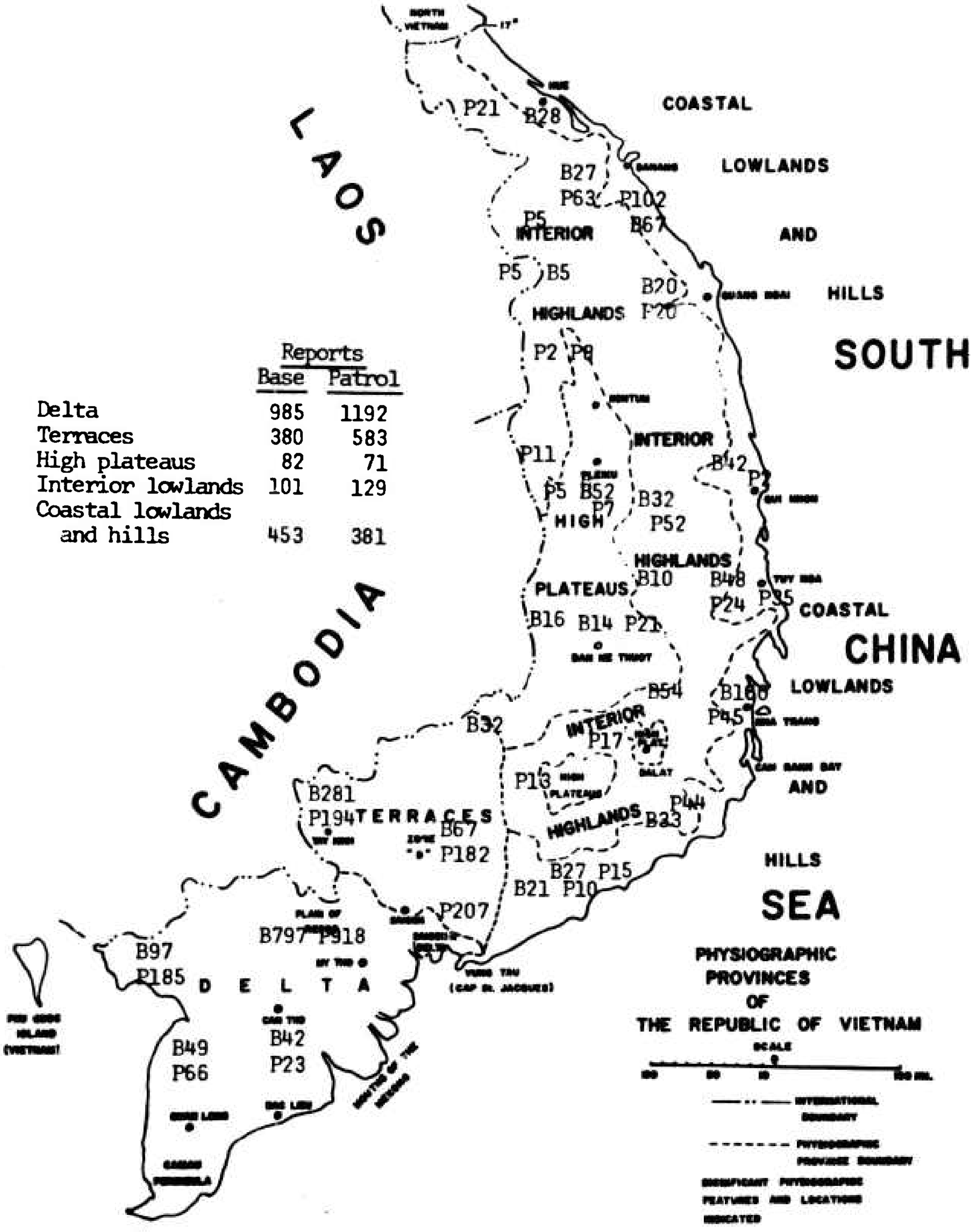
VIETNAMESE COMMUNICATIONS EQUIPMENT

Table 1 presents a listing of communications equipment in use in

FIGURE 1

Geographic Distribution of Field Data Collection
15 January 1967

	Reports Base	Reports Patrol
Delta	985	1192
Terraces	380	583
High plateaus	82	71
Interior lowlands	101	129
Coastal lowlands and hills	453	381



Vietnam by Vietnamese military and paramilitary forces, police, and civil agencies. Much of this equipment is nominally obsolete but is still the mainstay of tactical communications throughout much of the world in addition to South Vietnam. Many items are not used in patrol operations, others are being phased out in favor of newer equipment. Some items, the AN/PRC-25 being the most obvious example, are used primarily by the U.S. advisory and support units working with the Vietnamese military and paramilitary forces. This list does not include the tactical communications equipment used exclusively by U.S. and FWF tactical units now operating in the Republic. The list is presented with this report for reference to the main features of sets examined in the tables which follow.

TYPICAL PATROL MISSIONS

The employment of communications equipment on a patrol or other small unit action is to a great extent dependent upon the mission of the patrol. For purposes of the data collection effort, Vietnamese missions based on observations in the field are typified below:

Reconnaissance. A unit with the primary purpose of the generation of intelligence and general reconnaissance of the terrain. Although not a fighting unit, a reconnaissance patrol in the Vietnamese Armed Forces is frequently fielded in strength to avoid being overrun in the case of an encounter with the enemy. Reconnaissance patrols may be foot (most typical), vehicle, or small naval river patrol craft.

Security patrols are of two major types. Some may be considered to be fixed security detachments, typically guarding a bridge or installation or securing the environs of an installation. Mobile security patrols may have the mission of securing a harvest, in which case they may keep the enemy either from the harvesting activity, the crop in transit, or the crop in local storage. Security patrols are typically dismounted but may employ vehicles or patrol craft.

Ambush patrols have the mission of enemy contact by the classic tactics of ambush. They are established in sufficient strength to have an advantage in shock effect and firepower over the enemy. Ambush patrols are employed along enemy routes of movement or avenues of potential enemy approach to friendly installations. Ambush patrols are almost always dismounted.

Escort patrols are composed to provide strength and firepower to allow passage of friendly forces or civilians not so equipped.

TABLE 1

Characteristics of Communications Equipment

Nomenclature	Type	Frequency Range (MHz)	Modulation	Power (watts)
Village-Hamlet Radios				
HT-1	R-T	30-40	AM	0.5
TR-5	R-T	30-40	AM	5
TR-10	R-T	3-12	AM	5
TR-20	R-T	30-40	AM	20
TR-35	R-T	2-9	AM	30
National Police Radios				
FM-1	R-T	152.8-162.0	FM	1
FM-5	R-T	152.8-162.0	FM	5
Motran	R-T	152.8-162.0	FM	30
Tactical Radios				
AN/PRC-6	R-T	47-55.4	FM	0.25
AN/PRC-9	R-T	27-38.9	FM	1
AN/PRC-10	R-T	38-54.9	FM	1
AN/PRC-25	R-T	30-75.95	FM	1.5-2.0
AN/PRC-28	R-T	30-42	FM	1
AN/PRC-47	R-T	2-12	SSB	100 PEP
AN/GRC-5	R-T	27-38.9	FM	16
		47-58.4		0.5
AN/GRC-6	R-T	27-38.9	FM	16
		47-58.4		0.5
AN/GRC-9	R-T	2-12	AM	CW-15, V-7
AN/GRC-26, A,	T	2-18	AM	CW & FSK-
B and C	R	0.5-32		400, V-300
AN/GRC-38	T	2.0-18	AM	CW-400
	R	0.54-54		V-300
AN/GRC-41	T	1.5-20	AM	V-450
	R	0.5-32		CW-450
AN/GRC-87	R-T	2.0-12	AM	CW-15, V-7
AN/GRC-106	R-T	2.0-30	SSB	400 PEP,
				CW-200
AN/GRC-109	T	3.0-22		CW 10-15
	R	3.0-24		

Table 1 Continued

Nomenclature	Type	Frequency Range (MHz)	Modulation	Power (watts)
AN/GRC-125	R-T	30-76	FM	1.5
AN/VRC-9	R-T	27.0-38.9	FM	16
AN/VRC-10	R-T	38-54.9	FM	16
AN/VRC-12	R-T	30-76	FM	35
AN/VRC-15	R-T	38-54.9	FM	16
AN/VRC-17	R-T	27-38.9	FM	16
AN/VRC-18	R-T	38-54.9	FM	16
AN/VRC-34	R-T	2-12	AM	CW-15, V-7
AN/VRC-38	T	1.5-20	AM	100
	R	0.5-32		
AN/VRQ-2	R-T	27-38.9	FM	16
AN/VRQ-3	R-T	38-54.9	FM	16
SCR-193	R	BC-312 see Transmitters and BC-191 Receivers below		
SCR-188	Same as SCR-193 except AC powered for fixed installations			

Radio Relay Equipment

AN/TRC-1	Radio relay set	70-100	FM	40
AN/TRC-3	Radio relay tml	70-100	FM	40
AN/TRC-4	Radio relay repeater	70-100	FM	40
AN/TRC-24	Radio relay set	50-upwards	FM	50-120
AN/TRC-35	Radio relay tml	50-upwards	FM	50-120
AN/TRC-36	Radio relay repeater	50-upwards	FM	50-120
AN/TRC-29	Radio relay set	1700-2400	FM	10
AN/TRC-38	Radio relay tml	1700-2400	FM	10
AN/TRC-39	Radio relay repeater	1700-2400	FM	10

Transmitters

BC-191	T	1.5-6.2	AM	CW-75, V-40
BC-610	T	2-18	AM	CW-400, V-300

Receivers

R-390/URR	R	0.5-32	-	-
R-388/URR	R	0.5-30.5	-	-
BC-312	R	1.5-18	-	-
BC-342	R	1.5-18	-	-

Table 1 Continued

Nomenclature	Type	Frequency Range (MHz)	Modulation	Power (watts)
Aircraft Radios				
AN/ARC-1	R-T	100-156	AM	6
AN/ARC-3	R-T	100-156	AM	8
AN/ARC-12	R-T	0.19-0.55	AM	2
		116-148		
AN/ARC-36	R-T	100-156	AM	8
AN/ARC-44	R-T	24-51.9	FM	6-8
AN/ARC-45	R-T	225-400	AM	2
AN/ARC-27/55	R-T	225-400	AM	9
AN/ARC-54	R-T	30-69.95	FM	10
AN/ARC-60	R-T	228-258	AM	0.5
AN/ARC-73	R-T	116-149.95	AM	20-25
AN/ARC-302A	R-T	118-136	AM	-
AN/ARC-302H	R-T	118-136	AM	-
Navy Radios				
Transceivers				
TCS-12	R-T	1.5-12	AM	CW-5, V-45
TCS-13	R-T	1.5-12	AM	CW-25, V-15
TCS-14	R-T	1.5-12	AM	CW-25, V-15
TCS-15	R-T	1.5-12	AM	CW-25, V-15
SCR-694	R-T	3.8-6.5	-	CW-25, V-7
Transmitters				
TDE	T	0.3-18.1	AM	100-A1
TED	T	225-400	AM	10

Typically vehicular mounted in either armored cars or jeeps, these patrols are sufficiently well armed to perform their escort role but their primary mission is not contact. Dismounted escort patrols may be used to move civilians from threatened areas; to escort prisoners of war, and to escort vital supplies and materiel.

Search patrols have the mission of reconnaissance plus the mission of enemy destruction if he is encountered. Search patrols may be dismounted or waterborne, but rarely operate with vehicles.

Other patrol types include those which did not report their mission on the original data sheets; those engaged in special missions such as long range or "recondo" operations; operations in which a company or even a battalion operated independently and reported their communications activity even though their operation could not, strictly speaking, be termed a patrol, and a few point-to-point operations such as outpost to base.

SIZE, MISSION, RADIO TYPES

Table 2 and Figure 2 present the composition of Vietnamese patrols by mission, size and radio types, based on the more than 2,000 line items of patrol data examined. It may be noted from Table 2 that the AN/PRC-10 patrols are more frequently true small unit or patrol type operations, whereas the units carrying the heavier and bulkier AN/GRC-9 and AN/GRC-87 high frequency (HF) radios typically approach company or even battalion size operations.

PATROL COMMUNICATIONS EFFECTIVENESS

Tables 3 and 4 examine patrol communications effectiveness on the basis of data received and processed to date. It will be noted that the sample size varies with each examination, reflecting the data which was actually reported on the data sheets. A successful contact is defined as a series of transmissions or receptions which result in the passing of information to the satisfaction of the units involved. Conversely, an unsuccessful contact occurs when units fail to pass information to their satisfaction. There are no intermediate categories. In these and following tables, successful radio contact is shown by "S" and unsuccessful contact by "U".

Table 3 examines patrol communications effectiveness by unit mission and radio type. The AN/PRC-10 radio is shown to be the mainstay of small unit communications among the Vietnamese forces and accounts for between 50 and 60 percent of all communications examined. The two HF tactical radios, the AN/GRC-9 and AN/GRC-87

TABLE 2

Composition of Vietnamese Patrols by Mission and Communications Effectiveness (See Figure 2)

Type of Patrol	Ave No of Men	Total No of Patrols	Average Successful Contacts Per Patrol	Average Unsuccessful Contacts Per Patrol	Percent Successful Contacts
AN/PRC-10 Equipped					
Recon	71	31	9	.68	93
Security	26	50	5.1	1.2	81
Ambush	48	21	7.4	.62	92
Escort	32	16	7.8	.94	89
Search	85	14	10.5	1.36	89
Other	59	2	6.5	0	100
AN/PRC-25 Equipped					
Security	10	1	5	0	100
AN/GRC-9 Equipped					
Recon	240	6	8.33	0	100
Security	349	12	6.5	1.0	87
Ambush	760	2	20.5	0	100
Escort	59	23	8.78	.56	94
Search	126	9	7.78	.55	93
Other	354	2	6.5	0	100
AN/GRC-87 Equipped					
Recon	63	4	15.5	0	100
Security	156	8	8.3	1.75	83
Escort	105	5	8.2	3.6	69
Search	150	7	6.4	1.7	79
AN/PRC-6 Equipped					
Ambush	15	1	5	0	100
SCR-193 Equipped					
Escort	2	1	12	0	100
TCS Equipped					
Recon	10	1	3	0	100
Search	30	1	0	13	0

FIGURE 2

Vietnamese Patrol Size
Distribution All Missions

217 Patrols Examined

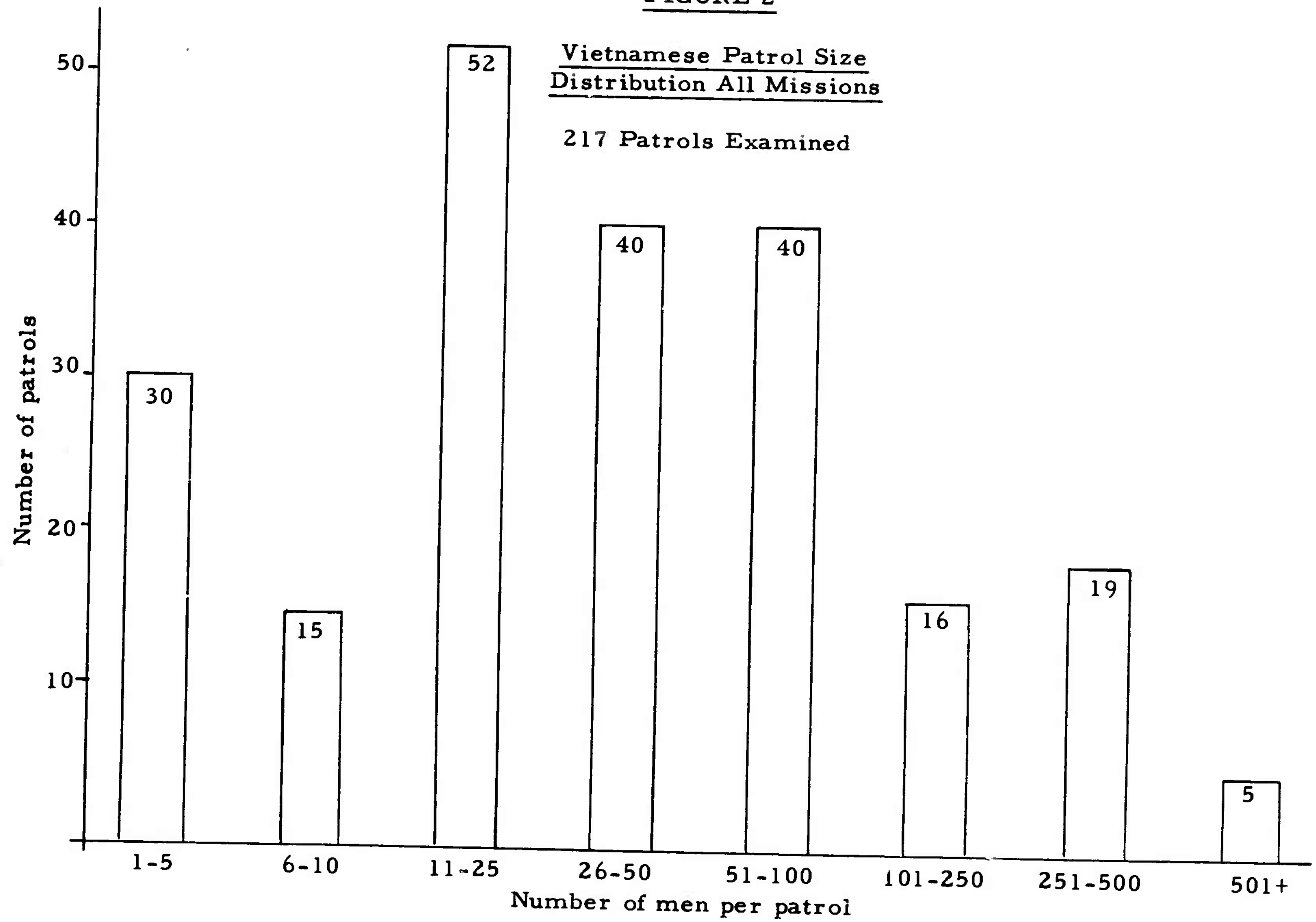


TABLE 3

Vietnamese Patrol Communications Effectiveness by Unit Mission and Radio Type

2191 Communications Examined

Radio	Recon Contact			Security Contact			Ambush Contact			Escort Contact			Search Contact			Other Contact			Mission not rptd Contact		Total Contact		
	S	U	%S	S	U	%S	S	U	%S	S	U	%S	S	U	%S	S	U	%S	S	U	S	U	%S
AN/PRC-10	296	21	93	276	65	81	175	13	93	134	15	90	170	23	88	22	0	100	58	5	1131	142	89
AN/PRC-25	-	-	-	5	0	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	0	100
AN/GRC-9	67	3	96	85	12	88	41	0	100	226	13	95	99	11	90	13	0	100	7	3	538	42	93
AN/GRC-87	62	0	100	68	16	81	-	-	-	65	20	76	55	14	80	-	-	-	-	-	250	50	83
AN/PRC-6	-	-	-	-	-	-	5	0	100	-	-	-	-	-	-	-	-	-	-	-	5	0	100
TR-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TCS	3	0	100	-	-	-	-	-	-	-	-	-	0	13	0	-	-	-	-	-	3	13	19
SCR-193	-	-	-	-	-	-	-	-	-	12	0	100	-	-	-	-	-	-	-	-	12	0	100
Total	428	24	95	434	93	82	221	13	94	437	48	90	324	61	84	35	-	100	65	8	1944	247	89

represent 30 percent of the communications reported, while the remaining 10-20 percent are divided among HF and very high frequency (VHF) ground and naval radio equipment.

Table 4 examines 2118 patrol-originated communications from the point of view of patrol type, mission, and antenna used. More than 50 percent of the patrol communications were performed with the AN/PRC-10 and the long whip was the most popular antenna. A success to failure ratio of approximately 8:1 resulted with the long whip antenna. Success with the tape antenna, although used less than half as frequently,was 12:1. This may mean that the long whip was correctly used in more marginal communication environments in which use of the tape antenna would not have been contemplated. Because of the numerous configurations possible with a wire antenna, it was not practical to record the type of wire antenna used.

Table 5 reports the effects of the physical environment at the patrol site, by unit mission and radio type. No particular pattern of operation is deduced from this preliminary analysis since the overall effects of the physical environment, particularly on VHF patrol communications, includes the physiography at the patrol site, the physiography along the wave path, and the physiography at the base station. Under the path physiography analysis task, an attempt is being made to correlate these data.

BASE STATION COMMUNICATIONS EFFECTIVENESS

Tables 6 through 8 present data based upon examination of approximately 2,100 communications originating at base stations. The most significant difference is the use of the RC-292 antenna, a mast-mounted ground-plane installation common to units operating in a base or non-mobile mode. Radio equipment at base is essentially similar to that carried by patrol* with the exception of the power supplies for the AN/GRC-9 or AN/GRC-87 radios which may be operating from motor generators or vehicles.

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*This situation is not as prevalent at U.S. Army base installations where auxiliary-powered radios rather than battery-powered radios are the primary elements. In III Marine Amphibious Force (MAF), however, base stations in general use the same equipment (AN/PRC-25) as patrols and other forward elements of the battalion. At all these U.S. base stations both Army and Marine, it is usual for elevated RC-292 antennas to be used.

TABLE 4

Vietnamese Patrol Communications Effectiveness by Mission, Radio and Antenna Types

2118 Communications Examined

Radio and Antenna Type	Recon Contact S	Recon Contact U	Security Contact S	Security Contact U	Ambush Contact S	Ambush Contact U	Escort Contact S	Escort Contact U	Search Contact S	Search Contact U	Other Contact S	Other Contact U	Total Contact S	Total Contact U
AN/PRC-10														
Tape	111	6	74	10	132	11	9	-	54	5	-	-	380	32
Long whip	178	14	184	42	43	2	117	15	95	9	22	-	639	82
Wire	4	-	18	13	-	-	8	-	21	9	-	-	51	22
RC-292	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Not reported	3	1	-	-	-	-	-	-	-	-	-	-	3	1
Total	296	21	276	65	175	13	134	15	170	23	22	-	1073	137
AN/GRC-9														
Tape	-	-	7	1	-	-	19	-	17	-	-	-	43	1
Long whip	33	-	16	2	-	-	154	9	68	9	8	-	279	20
Wire	34	3	61	9	41	-	53	4	14	2	5	-	208	18
Not reported	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Total	67	3	85	12	41	-	226	13	99	11	13	-	531	39
AN/GRC-87														
Tape	-	-	-	-	-	-	24	2	-	-	-	-	24	2
Long whip	40	-	31	2	-	-	6	-	9	2	-	-	86	4
Wire	22	-	37	14	-	-	35	18	44	12	-	-	138	44
RC-292	-	-	-	-	-	-	-	-	2	-	-	-	2	-
Not reported	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	62	-	68	16	-	-	65	20	55	14	-	-	250	50
AN/PRC-25														
Tape	-	-	5	-	-	-	-	-	-	-	-	-	5	-
AN/PRC-6														
Tape	-	-	-	-	5	-	-	-	-	-	-	-	5	-
TCS														
Tape	-	-	-	-	-	-	-	-	-	9	-	-	-	9
Long whip	-	-	-	-	-	-	-	-	-	4	-	-	-	4
Not reported	3	-	-	-	-	-	-	-	-	-	-	-	3	-
Total	3	-	-	-	-	-	-	-	-	13	-	-	3	13
SCR-193														
Long whip	-	-	-	-	-	-	12	-	-	-	-	-	12	-
Grand Totals	428	24	434	93	221	13	437	48	324	61	35	-	1879	239

TABLE 5

Vietnamese Patrol Communications Effectiveness by Mission, Radio Type, and Physical Environment

Patrol Mission and Radio Type	Vegetation						Topography								Weather					
	Open		Brush		Trees		Flat		Valley		Hillside		Hilltop		Clear		Cloudy		Rain	
	Contact		Contact		Contact		Contact		Contact		Contact		Contact		Contact		Contact		Contact	
	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U
Reconnaissance																				
AN/PRC-10	77	9	89	7	98	4	212	18	14	0	7	0	18	0	222	9	45	12	0	0
AN/GRC-9	14	3	28	0	22	0	8	0	19	0	37	3	0	0	36	0	19	0	5	3
AN/GRC-87	3	-	59	-	0	-	12	-	0	-	30	-	20	-	52	0	8	0	0	-
TCS	-	-	-	-	3	-	3	0	0	0	0	0	0	0	-	-	-	-	-	-
Total	94	12	176	7	123	4	235	18	33	-	74	3	38	-	310	9	72	12	5	3
Security																				
AN/PRC-10	89	2	101	48	49	11	149	16	47	9	54	43	7	0	199	22	35	33	21	10
AN/PRC-25	1	-	-	-	-	-	5	-	0	-	0	-	0	-	5	-	0	-	0	-
AN/GRC-9	36	0	24	8	17	4	62	7	6	3	9	2	7	0	84	10	0	2	0	-
AN/GRC-87	14	-	38	11	4	-	19	12	1	0	21	0	18	1	48	7	12	7	5	1
Total	140	2	163	67	70	15	235	35	54	12	84	45	32	1	336	39	47	42	26	11
Ambush																				
AN/PRC-10	32	7	150	6	10	5	163	13	0	0	0	0	0	0	116	13	44	0	3	0
AN/GRC-9	0	0	12	0	0	0	41	-	0	-	0	-	0	-	49	-	2	0	-	-
AN/PRC-6	2	0	1	0	2	0	5	-	0	-	0	-	0	-	4	-	1	0	-	-
Total	34	7	163	6	12	5	209	13	0	-	0	-	0	-	169	13	47	0	3	-
Escort																				
AN/PRC-10	92	0	24	3	15	12	122	15	2	0	8	0	0	0	127	15	5	0	2	0
AN/GRC-9	100	3	83	0	26	9	118	13	3	-	72	0	30	0	165	6	20	4	9	3
AN/GRC-87	35	12	9	0	12	2	9	6	5	2	27	10	0	0	50	10	14	10	1	-
SCR-193	0	-	12	-	0	-	12	0	0	-	0	0	0	0	9	0	3	0	-	-
Total	227	15	128	3	53	23	261	34	10	2	107	10	30	0	351	31	42	14	12	3
Search																				
AN/PRC-10	68	6	80	13	0	0	58	13	21	0	53	10	19	0	113	13	46	1	5	8
AN/GRC-9	9	6	46	1	20	2	0	0	24	1	55	9	0	0	52	1	21	7	9	3
AN/GRC-87	20	3	26	9	5	2	1	0	26	9	12	5	0	0	28	3	25	10	1	1
TCS	0	-	0	-	0	-	0	13	0	0	0	0	0	0	13	13	-	-	-	-
Total	97	15	152	23	25	4	59	26	71	10	120	24	19	0	206	30	92	18	15	12
Other																				
AN/PRC-10	9	-	13	-	0	-	22	0	0	0	0	0	0	0	22	0	0	-	-	-
AN/GRC-9	9	-	1	-	3	-	13	0	0	0	0	0	0	0	13	0	-	-	-	-
Total	18	-	14	-	3	-	35	0	0	0	0	0	0	0	35	0	-	-	-	-

Table 6 presents the record of 2,141 communications originating from base stations. Again the AN/PRC-10 accounts for approximately 50 percent of the communications reported. The RC-292 antenna provides the highest success percentage followed by the tape antenna with the AN/PRC-10.

Table 7 examines the effectiveness of 2,062 base station communications by modulation type. Unlike comparable U.S. forces, the Vietnamese make considerable use of continuous wave (CW) at the small unit level and, according to many U.S. advisors interviewed, are able to establish effective communications using this mode under circumstances when all other methods of radio communication have failed.

Table 8 shows base station communications effectiveness by radio type and physical environment.

OBSERVATIONS ON VIETNAMESE COMMUNICATIONS PRACTICES AND PROBLEMS

GENERAL

During the past 18 months, numerous visits have been made by the study team to Vietnamese military and paramilitary units in the field. Extensive discussions were held with Vietnamese military personnel and with their U.S. advisors at all levels.

The observations presented below are intended to serve two purposes. First, they will provide a background for the data presented in the preceding portion of this chapter so that some aspects of the nature of the tactical environment in which these data were generated may be understood. Second, they will highlight communications practices and problems among Vietnamese tactical units. They are, however, a record of observations made by Vietnamese and U.S. advisory personnel in the field, and therefore are valid on the basis of actual tactical experience. They provide information which should be of interest to tactical commanders and their communications personnel.

It is again stressed that these practices and problems are those reported by the Vietnamese forces and do not necessarily reflect actions of U.S. units. For example, Vietnamese forces rarely move field artillery in support of operations. On the other hand, the mobility of U.S. field artillery, particularly after the CH-47 (Chinook) helicopter became available in quantity, is one of the most significant aspects of U.S. tactics. As another example, the Vietnamese are

TABLE 6

Vietnamese Base Station Communications Effectiveness by Radio and Antenna Type

2141 Communications Examined

Radio and Antenna Type	Successful	Unsuccessful	Not Rptd	Percent Successful	No. of Comm. Examined
AN/PRC-10			48		
Tape	458	48		90.5	
Long whip	276	67		80.5	
Wire	67	19		77.9	
RC-292	156	13		92.3	
Total	957	147	48	86.7	1,152
AN/PRC-25			-		
Tape	23	1		95.8	
Long whip	19	-		100.0	
RC-292	12	-		100.0	
Total	54	1	-	98.2	55
AN/GRC-9			12		
Tape	22	3		88.0	
Long whip	38	1		97.4	
Wire	506	40		92.7	
RC-292	9*	-		100.0	
Total	575	44	12	92.9	631
AN/GRC-87			-		
Tape	11	4		73.3	
Long whip	1	0		100.0	
Wire	200	12		94.0	
Total	212	16	-	93.0	228
AN/GRC-5					
RC-292	2	-	-	100.0	2
AN/PRC-6					
Tape	18	18	-	50.0	36
TR-20					
Wire	21	-	-	100.0	21
TCS					
Wire	3	-	-	100.0	3
Other					
Tape	13	-	-	100.0	13
Grand Total	1,855	226	60	89.1	2,141

*Questionable

TABLE 7

Vietnamese Base Station Communications Effectiveness by Radio and Modulation Type

2062 Communications Examined

Radio	AM Voice Contact S	AM Voice Contact U	AM Voice Contact %S	FM Voice Contact S	FM Voice Contact U	FM Voice Contact %S	CW Contact S	CW Contact U	CW Contact %S
AN/PRC-10	-	-	-	930	108	89.5	-	-	-
AN/PRC-25	-	-	-	54	1	98.2	-	-	-
AN/GRC-9	64	16	80	-	-	-	523	28	94.9
AN/GRC-87	3	-	100	-	-	-	208	16	92.9
AN/GRC-5	-	-	-	2	-	100	-	-	-
AN/PRC-6	-	-	-	18	-	100	-	-	-
TR-20	21	-	100	-	-	-	-	-	-
TCS	-	-	-	-	-	-	3	-	100
Other	13	-	100	-	-	-	-	-	-
Total	101	16	86.3	1004	109	90.2	734	44	94.3

TABLE 8

Vietnamese Base Station Communications Effectiveness By Radio Type and Physical Environment

Weather - 1870 Communications Examined
Topography - 1890 Communications Examined
Vegetation - 1791 Communications Examined

Radio Type	Weather						Topography								Vegetation					
	Clear Contact		Cloudy Contact		Rain Contact		Flat Contact		Valley Contact		Hillside Contact		Hilltop Contact		Open Contact		Brush Contact		Trees Contact	
	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U	S	U
AN/PRC-10	704	75	122	28	25	11	769	67	24	20	49	5	42	5	308	26	381	56	171	13
AN/PRC-25	41	-	3	-	8	1	31	-	4	-	19	1	-	-	23	-	20	1	11	-
AN/GRC-9	448	9	97	5	23	-	445	9	43	28	56	4	20	-	347	9	93	2	97	7
AN/GRC-87	156	2	37	10	7	1	185	5	8	4	18	6	-	-	84	3	24	-	80	9
AN/GRC-5	2	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-
AN/PRC-6	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TR-20	21	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	7	-	14	-
TCS	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Other	7	-	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1400	86	263	43	65	13	1451	81	79	52	142	16	64	5	764	38	528	59	373	29

equipped with second-hand radios and this may be significant. The performance of the AN/PRC-10, their small unit tactical set, falls far below that of the AN/PRC-25 as furnished to U.S. and allied units*. This lower capability is reflected in shorter communication ranges, and a much higher dependency upon HF-AM (amplitude modulation) and HF-CW (continuous wave) communications than is found with U.S. units.

USE OF AIRBORNE RELAYS

Range limitations of the AN/PRC-10 carried by Vietnamese ground troops has placed a heavy dependence upon the employment of airborne relays. This capability is available on a limited basis primarily in preplanned operations when forward elements are expected to operate at ranges in excess of the ability of the command post to maintain control using AN/PRC-10's. Relay aircraft are typically 0-1 (L-19) fixed-wing aircraft or UH-1 helicopters attached for the operation. Messages are repeated either with the aircraft's own radio or by man-pack radios such as the AN/PRC-10 or AN/PRC-25 carried aloft.

This technique usually works effectively and greatly extends VHF-FM communications, particularly in the delta region, so that command and control of forward elements may be maintained. It does, however, cause interference problems. As the aircraft gains altitude in order to maintain command communications, it may receive strong signals from operations elsewhere in the country. The airborne relay in the transmit role, by the same token, may deliver its signal to distant areas causing interference to other stations. In recent months, the massive build-up of the U.S. and allied forces with new and more powerful radios and high usage of aircraft has increased this problem for Vietnamese military and paramilitary forces.

VIETNAMESE RELIANCE ON U.S. ADVISORY RADIO NET

In almost every unit visited or operation monitored there appeared to be a strong reliance by the Vietnamese commanders upon the U.S. advisory net as supplemental to their own. Many Vietnamese unit commanders clearly lacked confidence in their AN/PRC-10 net and requested the U.S. advisor to pass commands from the command post (CP) to the U.S. advisor accompanying the forward units via the advisory AN/PRC-25 nets. The effectiveness of this system varied with the degree of cooperation provided by the advisors. Some advisors felt that this system worked to the detriment of the development

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*Republic of Korean forces in Vietnam are currently equipped with the AN/PRC-10.

of Vietnamese communications. Requests for substitution of the AN/PRC-25 for the AN/PRC-10 were heard almost universally.

Some competent and appropriately motivated Vietnamese commanders and signal officers were able to keep their AN/PRC-10's in good order and were able to use them effectively and efficiently. Others stated that the bulk of their equipment was usually out of order and that they had ceased to depend on their AN/PRC-10's in favor of visual or audio signals.

It was observed that the AN/PRC-10 is often plagued by battery problems. One reason, advanced by a signal officer of the 23rd Division in Ban Me Thuot, is that "supply" normally issues the oldest batteries first. The unit receives adequate stocks of new batteries, but they stay on the shelf until all the older batteries are issued. Batteries so issued are typically nearing the end of their shelf life.

COMMAND AND CONTROL WITHIN SMALL UNITS

The AN/PRC-6 "handie-talkie" radio was universally condemmed as too heavy, considering its performance. It is rarely used as it was said to be awkward and unreliable. This has posed command and control problems within units of platoon size. The problems have been only partially alleviated by the use of audio or visual signals. In a small unit on ambush, for example, every man must be ready to bring his weapon to bear in an instant. The awkward listening position required for the operator of an AN/PRC-6 (similar to holding a heavy and over-sized telephone headset to the head at all times) makes use of this set on such an operation impractical. One Vietnamese ranger commander in the delta, in establishing an ambush, actually lays field wire to coordinate his fire support.

The (then) developmental AN/PRT-4, AN/PRR-9 helmet radio combination was suggested by many for the ambush role.

USE OF HF RADIO

In the III Corps area, which includes the jungled terraces north and east of Saigon and the extensive areas of rubber plantations in the same general region, vegetation rather than terrain has been reported as being the primary limit on tactical VHF radio*. Even the U.S.

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*Detailed physiographic analysis of numerous Vietnamese radio communications in this region is now being carried out. See physiographic chapter.

advisors in this region using the AN/PRC-25 reported being "taken out" by vegetation at very short ranges. Extensive dead or marginal zones, primarily based on vegetation in this region, were also reported. For this reason, even on company-sized operations (generally 200 men or less) the AN/GRC-9 or AN/GRC-87 radio is carried. Officers operating in this area made a strong case for a smaller, lighter, man-pack HF radio. It was emphasized that the AN/GRC-9 (87) is a three-man load, yet the desire for reliable communications in areas of dense vegetation cover made these units accept the penalty of the weight and bulk of the AN/GRC-9(87) types of radio.

SOME SPECIAL VEGETATION EFFECTS

The adverse effects of rubber plantations along with jungle vegetation upon VHF radio communications in the III Corps area has been stated. III Corps officers reported, however, that in the rubber plantation area near Xuan Loc (about 60 kilometers east of Saigon) passable communications using the AN/PRC-10 were achieved beneath the canopy of the trees. They felt that the geometric alignment of the rows of rubber trees, together with the absence of undergrowth (see Photo 6, second Semiannual Report) allowed a relatively unobstructed wave path to be established.

In the III Corps area the effects of high reeds or rushes were reported as seriously limiting the VHF signal unless the antennas were elevated above the vegetation surface. Since the reeds in the Plain of Reeds* area may reach 10- or 12 feet in height this often was not possible. The result was that communications with the AN/PRC-10 were seriously degraded, despite the fact that the terrain is dead flat as are the ricelands immediately to the south. Ranges of from 3-5 kilometers were reported as being essentially the upper-bound in the Plain of Reeds using the AN/PRC-10.

FIELD ARTILLERY COMMUNICATIONS PROBLEMS

Employment of field artillery by the Vietnamese military and paramilitary forces differs markedly from the use of this arm in previous conflicts. A situation exists in which the tactical effectiveness of field artillery is seriously limited by range limitations in the highlands and the high plateaus, but exists to a lesser extent throughout the rest of the country.

The Vietnamese field artillery is usually not moved in support of an operation but remains in fixed, fortified positions in district

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*See Figure 19.

towns, provincial capitals and base camps. It is usually emplaced by piece (one gun) or by section (two guns). Each Howitzer covers a circular fire pattern to its maximum range. These circular zones typically overlap in the vicinity of towns and villages but gaps exist in areas of low population density.

Targets for field artillery are either acquired by intelligence, in which case unobserved fire is directed to map coordinates, or by contact with the enemy, in which case observed fire is adjusted on to the enemy target. It is in this latter case that deficiencies in field artillery radio communications have become evident. The forward artillery observer with the unit in contact must be able to adjust the fire visually and to communicate with the fire direction center to accomplish this mission. The fire direction center is usually located in proximity to the guns and has adequate communications on the artillery fire control net. The observer, on the other hand, may be required to adjust guns with ranges of from 10 to 15 kilometers with a radio which is severely limited by topography and vegetation, and may in some cases be capable of less than 5 kilometers effective range. Thus on many occasions the artillery observer is unable to adjust fire. The effective ranges of the guns have become the ranges of the fire control radios. The situation was effectively summed up by a regimental commander in the 23rd ARVN Division at Ban Me Thuot in the high plateaus. He stated, "My guns outrange my radios." His guns could fire over the jungle-covered mountains in his operational area, but his VHF radios could not give him the vitally needed fire direction and control.

Effective employment of radio relays would, of course, mitigate this problem. Vietnamese commanders stated, however, that except in some preplanned operations, airborne relays were usually not available on call. They further stated that they felt the vulnerability of ground relay stations to enemy attack could in many cases be countered only by an excessive commitment of troops to defend these installations.

U.S. AND ALLIED FORCES DATA COLLECTION PROGRAM

On 25 August 1966, the Director, ARPA, Project AGILE, requested that the title (schedule) of the contract be modified to read as follows:

> "a. To institute a program of information collection on the communications practices of patrols and other important small units in Vietnam; such units to be selected on a random-sample basis among RVNAF, U.S. and other friendly forces."

This modification reflected the increasing combat role being taken by U.S. and allied forces in Vietnam involving the employment of new equipment and the development of new tactics with increased firepower and mobility. It is apparent that these developments place a great dependence upon reliable, rapid, tactical communications. A revectoring of the data collection program was therefore undertaken. This involved a gradual de-emphasis of the collection of data from Vietnamese forces, and implementation of a data collection program from the U.S. and allied forces.

The new program required minor modifications in the data collection effort and revision of the coding forms. The latter reflected the differing TOE designations of the U.S. Army, U.S. Marines, Australian, New Zealand, and Korean units. The revised codes are shown in Appendix A.

Table 9 shows the record of visits to U.S. and other Free World Forces units made during this reporting period. The visits to units were made by two man teams and lasted from 2-4 days. The general pattern of the visits to tactical units was to go from higher level to lower, following the chain of command from division signal officer, brigade signal officer, battalion communications officer, company commanders, to communications NCOs. As each echelon was visited in the field on operation or at unit base, an informal interview was held with unit commanders, signal officers, senior signal NCOs, S-3s, and other communications personnel.

The purpose of the interviews was three-fold. First, to explain the objectives of the study and purposes of the data sheets which were to be left. Secondly, to establish a rapport with the personnel involved, thus hopefully increasing the acceptance and return of the data sheets. Thirdly, to obtain basic information about their units including tactics, radio nets, communications procedures, training of communications personnel, supply and maintenance problems, and comments on the equipment. Often in the course of these visits the team has been able to pass on information or suggestions from one unit to another thus increasing the overall acceptance of the study team and their task.

More than 1,500 line items of data have been received from U.S. and allied units. Coding is currently in progress but punch card preparation has not yet commenced. Thus information on communications practices among these units is limited to data gathered from interviews and observations made during the visits listed in Table 9.

A series of reports have been prepared on the communications

practices and problems of certain units visited. Examples of these are presented in Appendix B* covering the following units:

- 2/18 Infantry, 2nd Brigade, 1st Infantry Division
- 2/33 Field Artillery, 1st Infantry Division
- Long Range Reconnaissance Patrol Group, 1st Brigade, 101st Airborne Division
- 1st Battalion, 5th Regiment, 1st Marine Division

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*Appendix B (Confidential) is published separately.

TABLE 9

Visits to U.S. and Free World Forces Units

Unit	No of Visits Made	Reason for Visit
Hq I Field Force-Vietnam	1	Orientation coordination, no data sheet distribution at this level
Hq II Field Force-Vietnam	1	"
Hq III Marine Amphibious Force	1	"
1st Marine Division 1st Battalion, 5th Regiment 3rd Battalion, 5th Regiment 1st Battalion, 7th Regiment 2nd Battalion, 1st Regiment 1st Reconnaissance Battalion	1	Interview and data sheet distribution
3rd Marine Division 2nd Battalion, 9th Regiment 3rd Reconnaissance Battalion	1	Interview and data sheet distribution
2nd Brigade, ROK Marines 1st Battalion, 2nd Brigade	1	Interview and data sheet distribution
1st Infantry Division Hq Division Artillery 2/33 Field Artillery Battalion Division Signal Battalion 2nd Brigade 2/18 Infantry Battalion 3rd Brigade 1/16 Infantry Battalion 2/28 Infantry Battalion	2	Interview and data sheet distribution and pick-up
4th Infantry Division Division Artillery Division Signal Battalion 3rd Brigade, 25th Infantry Division 2nd Brigade, 2nd Battalion, 8th Infantry	1	Interview and data sheet distribution

Table 9 Continued

Unit	No of Visits Made	Reason for Visit
4th Battalion, 42nd Field Artillery		
1st Squadron, 10th Armored Cavalry		
1st Cavalry Division (Airmobile)	1	Interview and data sheet distribution
Division Signal Battalion		
3rd Brigade		
1st Battalion, 7th Cavalry		
5th Battalion, 7th Cavalry		
2nd Brigade		
1st Battalion, 5th Cavalry		
1st Brigade, 101st Airborne Division	2	Interview and data sheet distribution and pick-up
Long Range Reconnaissance Patrol Group		
1st Battalion, 327th Airborne Infantry		
2nd Battalion, 327th Airborne Infantry		
2/320 Field Artillery Battalion		
2nd Squadron, 17th Cavalry		
406th Radio Research Unit		
1st Australian Task Force	3	Interview and data sheet distribution and pick-up
Battalion - 5th Royal Australian Regiment		
Battalion - 6th Royal Australian Regiment		
Battery - New Zealand Artillery		
Hq 5th Special Forces Group	1	Interview and data sheet distribution and pick-up
Detachment A-502		
Detachment C-2		
Detachment A-251		
Detachment B-32		
Detachment B-312		
Detachment B-24		

DIALECT ANALYSIS

GENERAL

The purposes and methodology of the dialect study have been described in detail in the second Semiannual Report. The methodology of the data collection and the subsequent analyses may be summarized as locating and identifying the major language dialects which exist in South Vietnam today; recording of samples of these dialects; and determining their spectral content. The analyses have been completed during this reporting period. The requirement was to establish a data base so that research could determine the potential limitations which small unit tactical radio equipment now in use in Vietnam might impose upon intelligibility of the dialects examined. Communications system bandwidth frequency response capabilities of patrol radios was considered to be the major limiting factor. The study was also considered to be able to provide data for the design of optimum audio circuits and aid in the selection of modulation techniques for future radio equipment.

IDENTIFICATION OF MAJOR DIALECTS IN SOUTH VIETNAM

The initial approach to the identification of the major dialects was to generate a composite list of all dialects spoken in-country. This comprised 57 dialects of which 47 were from the Highland Tribal groups, 3 Vietnamese, 5 Chinese, and 2 Cambodian. The resulting composite list of dialects selected for analysis was as follows:

Vietnamese dialects: Northern, Central and Southern.

Cambodian dialect: Khmer Khrom.

Chinese dialects: Cantonese, Mandarin and Fukienese*.

Highland Tribal dialects: Jarai, Bahnar, Sedang, Rade, Cham, Koho and Hre.

COLLECTION OF VOICE RECORDINGS

Test messages were composed by an officer of the Vietnamese Army Signal Corps and Booz Allen staff personnel assisted by the Summer Institute for Linguistics of the North Dakota University and local missionaries.

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*Fukienese was included since the publication of the second Semiannual Report.

Fourteen different dialects were recorded throughout Vietnam with the use of an Akai X-IV portable tape recorder with a frequency response of 40 hertz to 25,000 hertz (± 3 dB). The Akai X-IV holds distortion to less than 2 dB in the 50-10,000 hertz range and holds at 2 dB in the 10,000 hertz - 20 kilohertz range (Figure 3). The microphone used imposed additional limitations. At the low frequency end of the speech spectrum, the response begins to fall off in the 150-200 hertz region and has dropped 10 dB at 50 hertz. At the HF end, above 6-7 kilohertz, the microphone displays considerable directional characteristics. However, on the average the response curve is flat out to 15 kilohertz.

ANALYSIS*

Each dialect sample was analyzed over the frequency range from 20 hertz to 20,000 hertz in 1.3 octave bands continuously spaced using a special scanning spectrum analyzer designed for high-speed, real-time analysis. In this analysis all spectrographic samples of each dialect, as processed by the 1/3 octave band analyzer, were stored in digital form on magnetic tapes on an IBM 1401 computer and these in turn were used to compute the mean spectrum distribution functions separately for the voiced and unvoiced utterances of that dialect.

The results of this analysis are presented in bar-graph form for each dialect in Figures 4 through 17.

CONCLUSIONS

1. The intelligibility of dialects which contain the higher occurrences of unvoiced utterances will be most affected by the limitation of bandwidth frequencies. Table 10 presents a breakout of the voiced utterances vs the unvoiced utterances for the 14 dialects tested as well as that of American English.

2. As can be seen from Table 10, the occurrence of unvoiced utterances in each dialect differs markedly from 9 percent for the Hre dialect of the Highland Tribes to 24 percent for the Mandarin dialect of the Chinese. A comparison of the utterance break-out for American English and the three dialects of the Vietnamese language reveals a striking similarity. It can be concluded that radio communication in the Vietnamese dialects will have the same degree of intelligibility as American English for whom the present-day radios have been designed.

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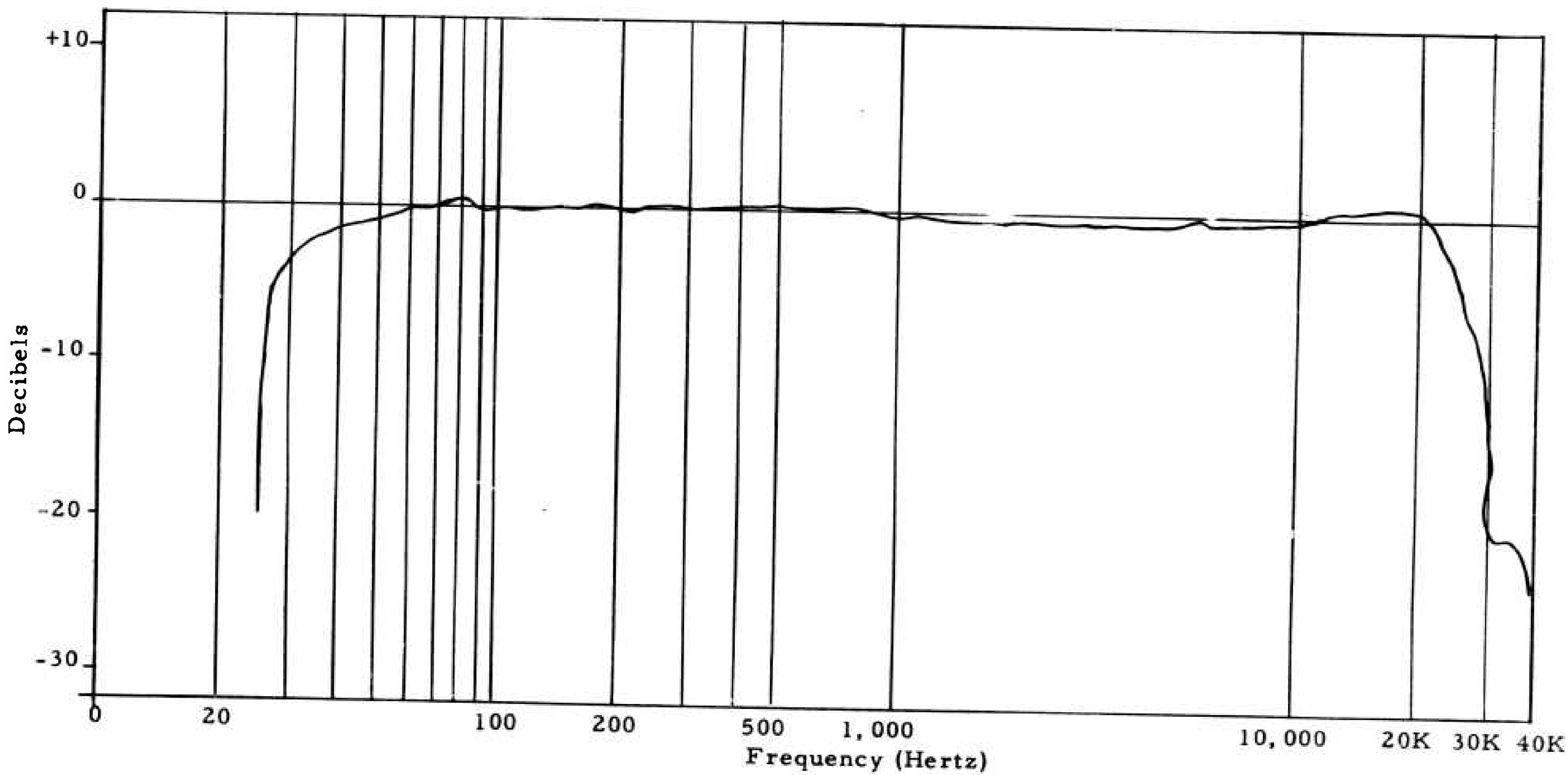
*Spectrographic Analysis of the voice samples was performed by Melpar Inc., under subcontract to Booz Allen Applied Research Inc.

FIGURE 3

Akai X-IV Tape Recorded Frequency Response at Tape Speed of 7.5 inches per second



3. Design limitations of communications system bandwidth to frequencies of 5,000 hertz and below will not impair the intelligibility of the voiced utterances of the dialects analyzed. Such limitations will, however, cause slight impairment of the unvoiced utterances, with consequent minor reduction in overall intelligibility. Any further reduction in the high frequency cut-off will most certainly mark the onset of significant intelligibility reduction with the toll being felt principally i the areas of unvoiced utterances. It is probable that for bandwidths of 2,000 hertz low-pass, virtually all information content carried by the unvoiced utterances of the dialects examined is lost; however, most of the information content of the voiced utterances would be retained under this same condition.

4. In general, the distributions of like utterances of each dialect possess the same general modal structure. The maximum energy for the voiced utterances occurs in the vicinity of 315 to 5,000 hertz with persistence to frequencies of 3,000 hertz and occasionally the occurrence of a second minor peak in the range between 1,000 and 3,000 hertz. The unvoiced utterances possess significant energy in the frequency range from 2,000 to 12,500 hertz.

5. The oriental dialects all possessed a common denomination in their characteristic utilization of short duration vocalic utterances punctuated by intervals of both silence and intense fricative*consonants. When compared to American English, the occurrence of the short vocalic utterance duration on the average of the oriental dialects examined, stands out as a strong differentiating element. Formant transitions, although they are indeed present in the oriental dialects, are not as prolonged in time duration as they are in typical American English. This latter characteristic is probably indicative of the strong dependence placed on tonal information in the oriental languages which results in a lesser dependence on formant transitional information for communications.

6. The intelligibility of the spoken version of the major Chinese and Vietnamese dialects have a high order of dependency on tone reproduction**. They may suffer some loss of message content in the use of

---

*Characterized by random noise-like sounds produced by air rushing through a constriction in the oral cavity formed by the lips or the tongue. For example, voiced fricative consonants are z in zero, ʒ in azure, v in voice and ð in then. Unvoiced fricative consonants are s in sit, ʃ in ship, f in fun, θ in theta and h in hall.

**See Appendix C.

single sideband voice transmission if the carrier reinjection is not stable, and inadvertent variable tonal distortions occur.

7. Difficulty may also occur in the transmission of these oriental dialects on equipment that uses the Random Access Discrete Address System (RADAS). These transmission systems may have a deleterious effect on the frequency stability of voice tone essential to the complete intelligibility of many of these dialects.

TABLE 10

Voiced Utterances vs the Unvoiced Utterances for the Tested Dialects and American English

Dialect	Voiced	Unvoiced
North Vietnamese	85%	12%
Central Vietnamese	88%	12%
South Vietnamese	86%	14%
Cambodian	90%	10%
Cantonese	84%	16%
Mandarin	76%	24%
Fukienese	85%	15%
Jarai	90%	10%
Bahnar	83%	17%
Sedang	88%	12%
Rade	89%	11%
Cham	87%	13%
Koho	86%	14%
Hre	91%	9%
American English	88%	12%

Graphic displays of distribution of energy by frequency of major Vietnamese, Cambodian, and Highland Tribal dialects of Vietnam.

Figure 4	North Vietnamese
Figure 5	Central Vietnamese
Figure 6	South Vietnamese
Figure 7	Cambodian
Figure 8	Cantonese
Figure 9	Mandarin
Figure 10	Fukienese
Figure 11	Jarai
Figure 12	Bahnar
Figure 13	Sedang
Figure 14	Rade
Figure 15	Cham
Figure 16	Koho
Figure 17	Hre

Note: In these graphs the abscissas represent the 1/3 octave band center-frequency values in hertz, while the ordinates represent the percent of energy values. The values for the voiced utterances are represented on these graphs by a solid line, while the unvoiced utterances are represented by a broken line. Wherever the two lines converge and appear to follow the same path, the solid line takes precedence in the graphic presentation.

FIGURE 4

North Vietnamese

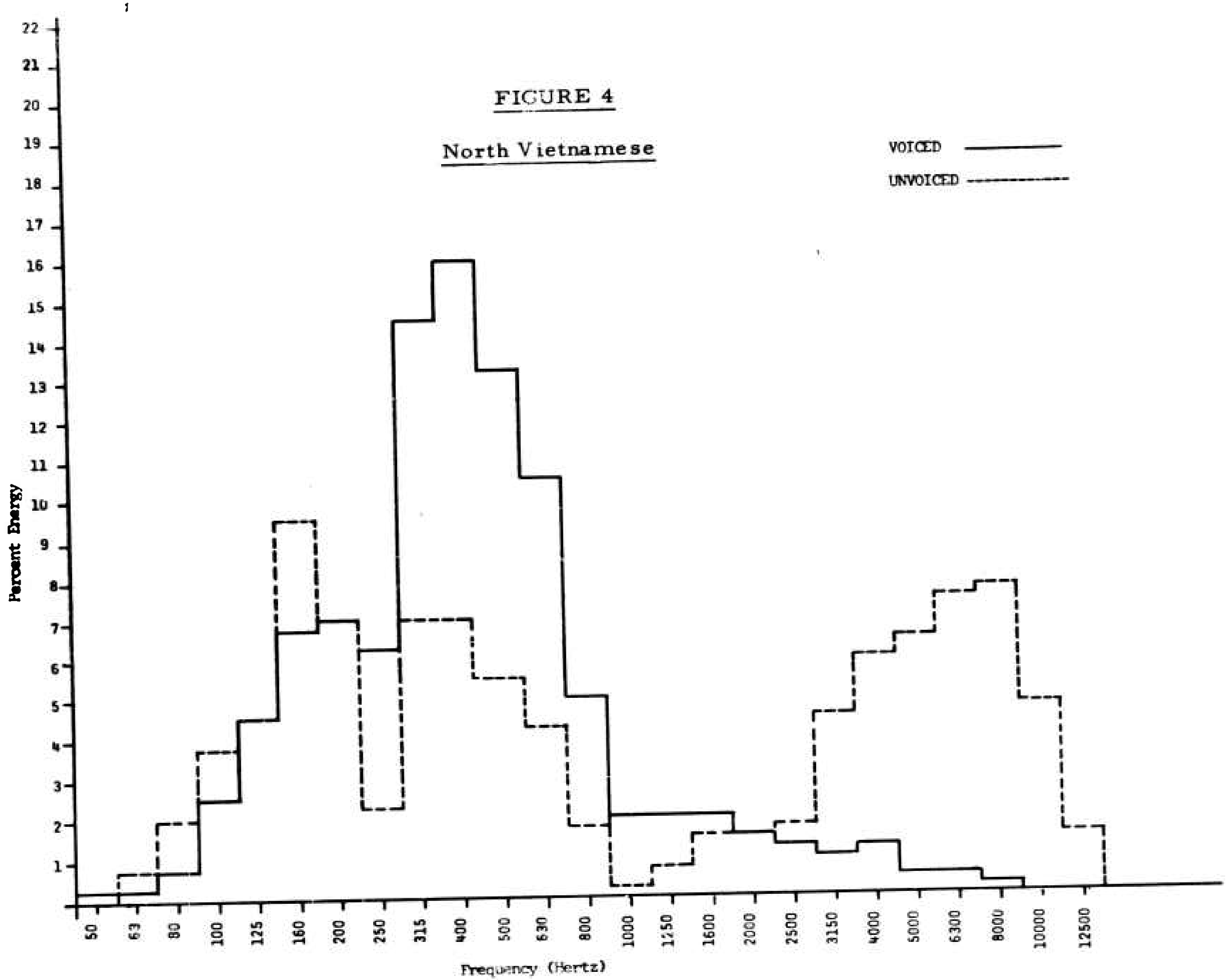


FIGURE 5

Central Vietnamese

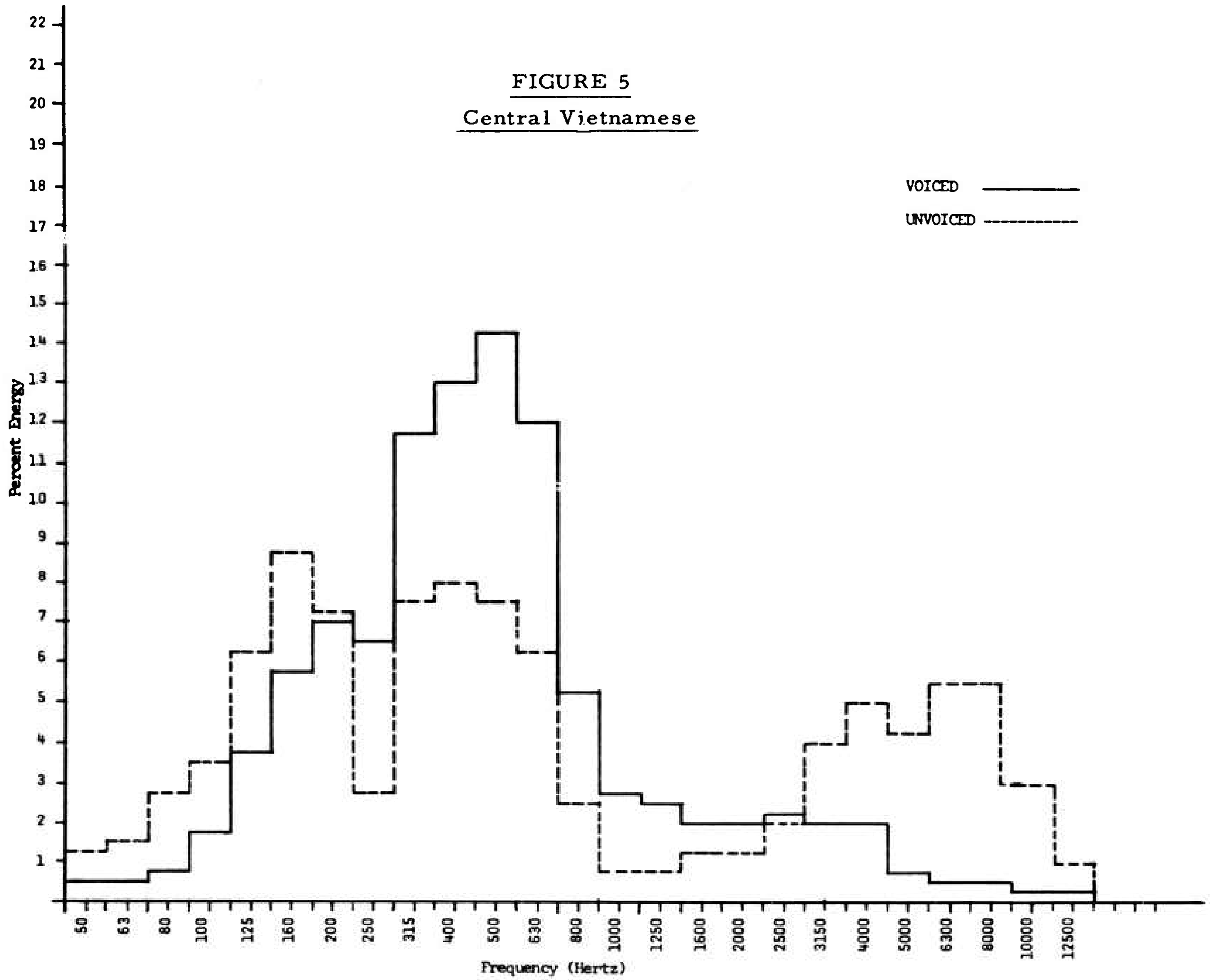


FIGURE 6

South Vietnamese

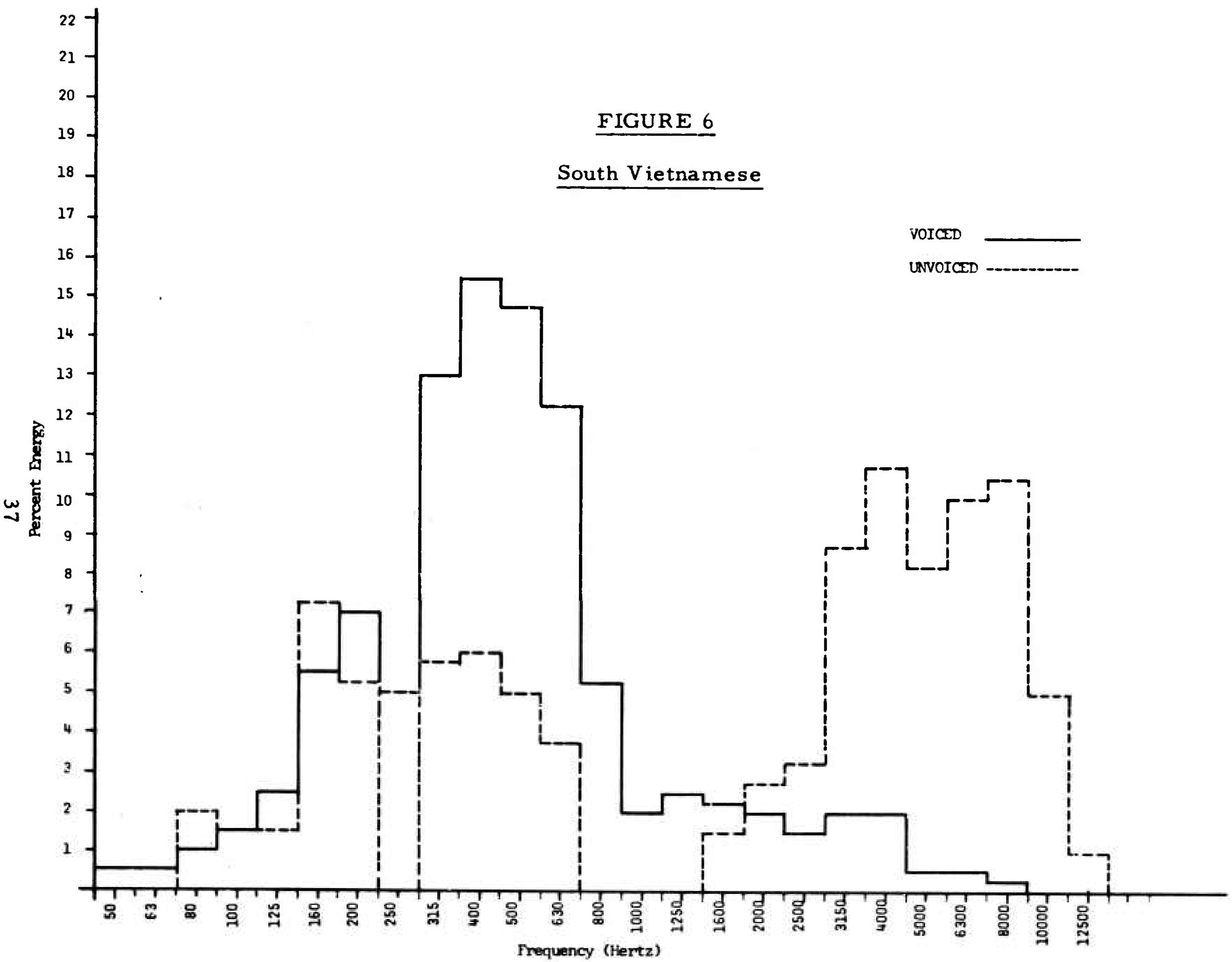


FIGURE 7

Cambodian

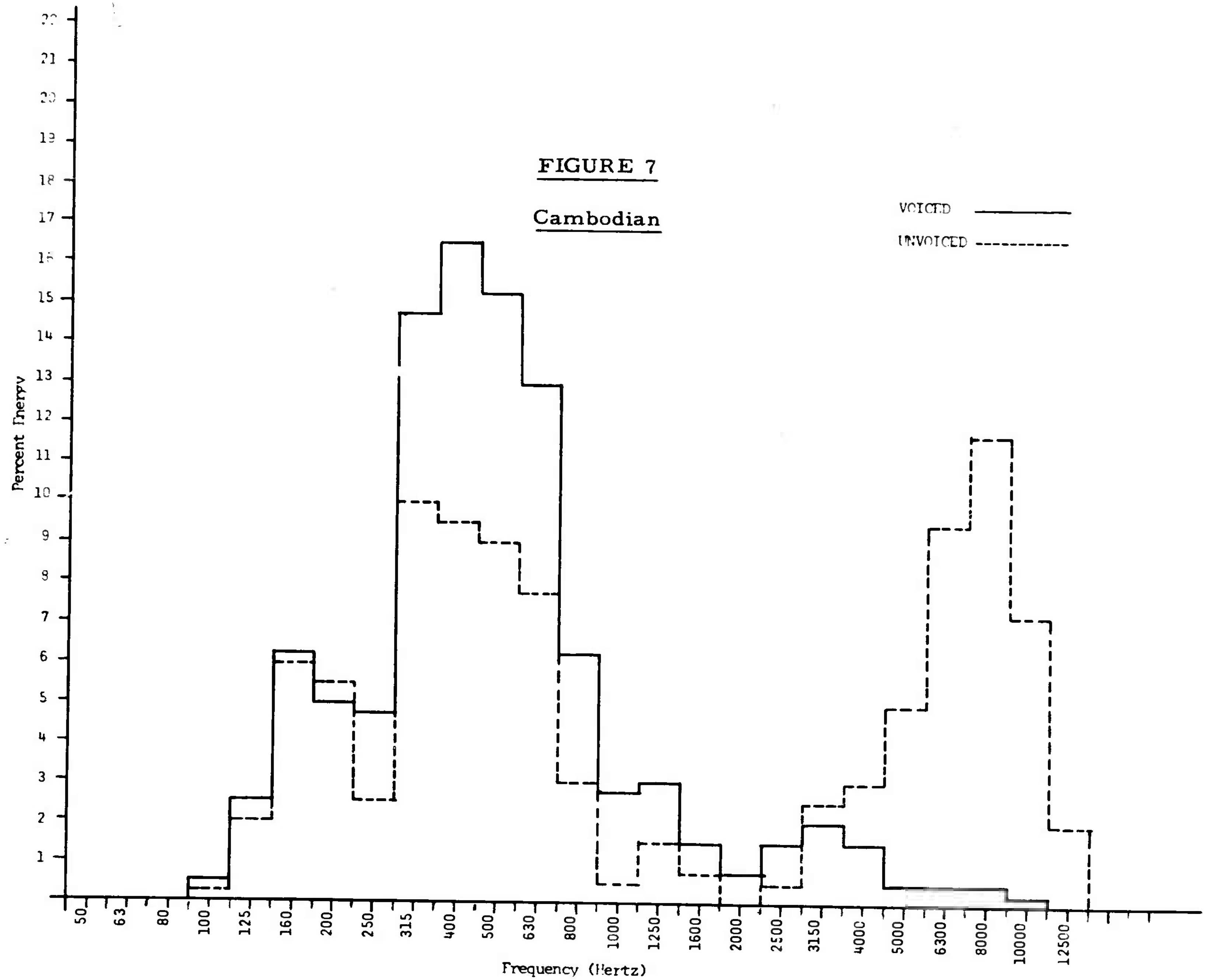


FIGURE 8

Cantonese

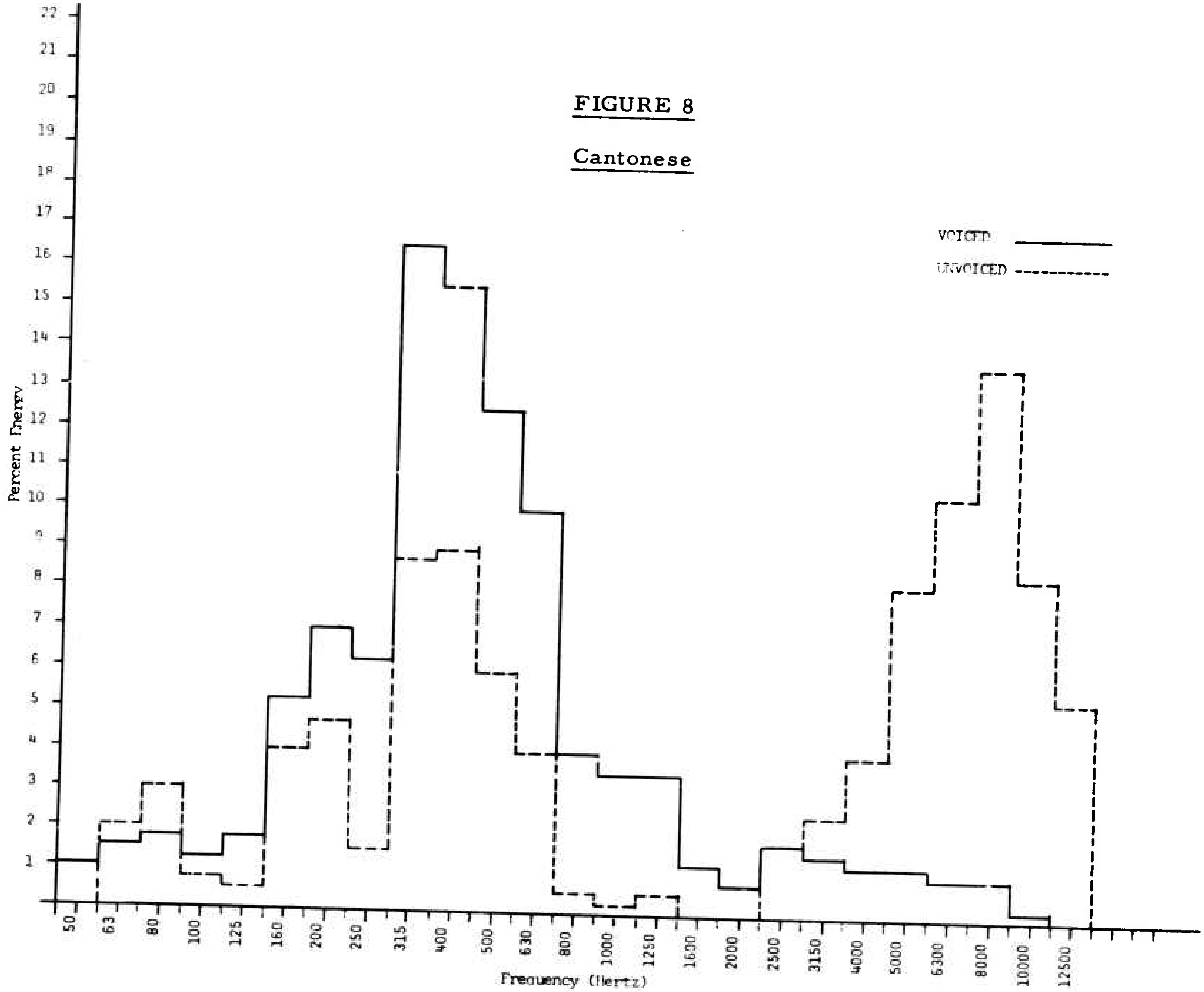


FIGURE 9

Mandarin

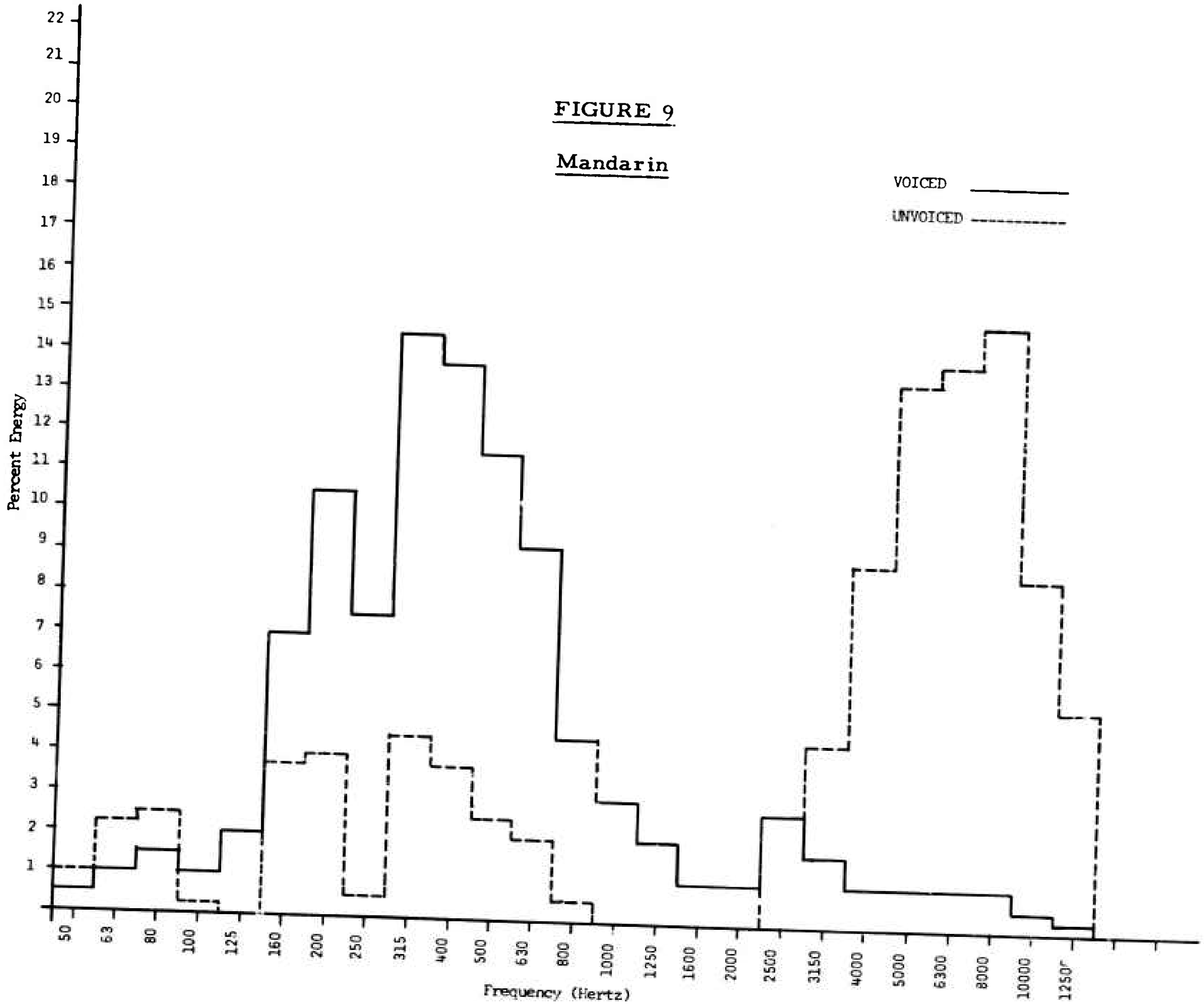


FIGURE 10

Fukienese

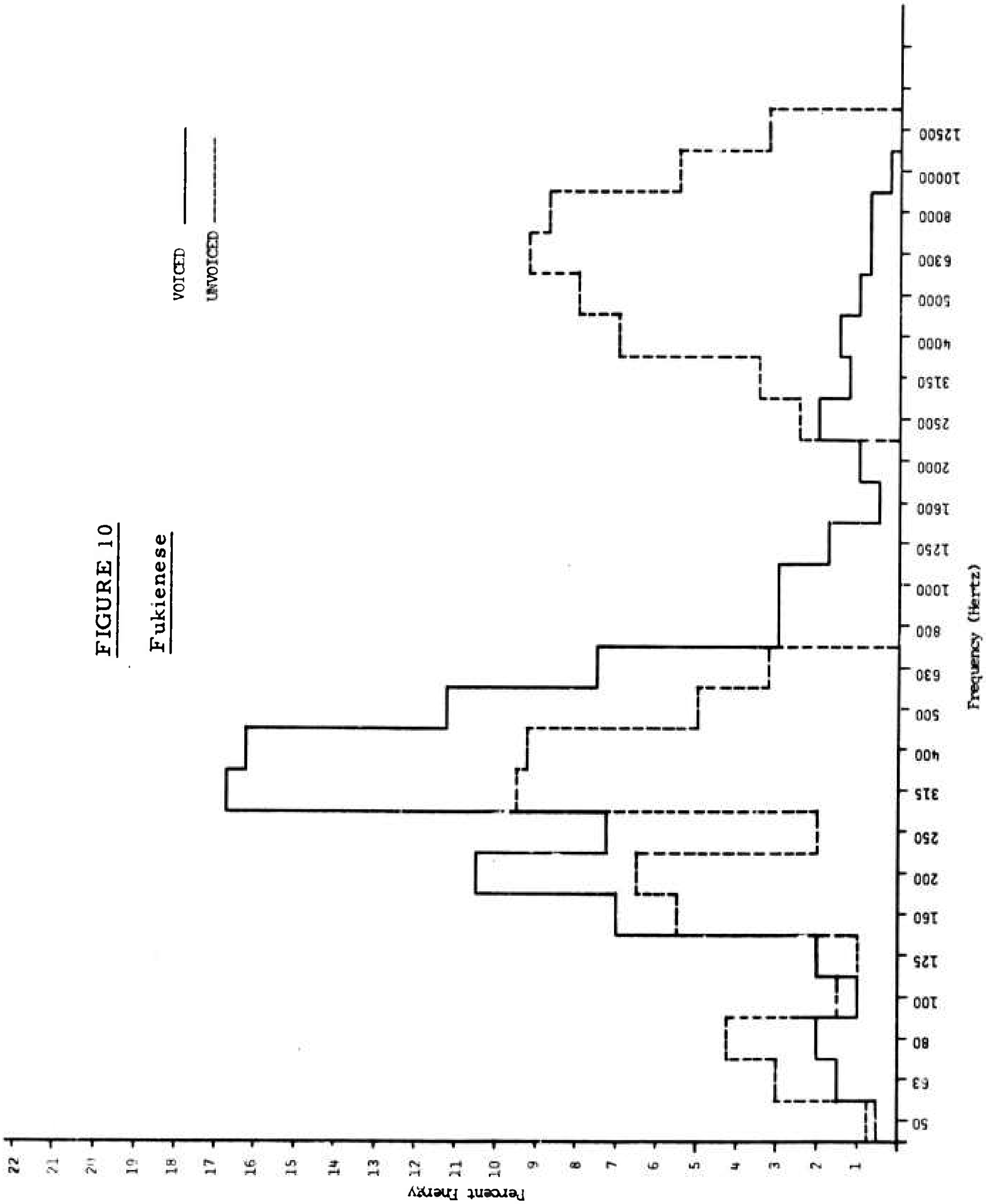
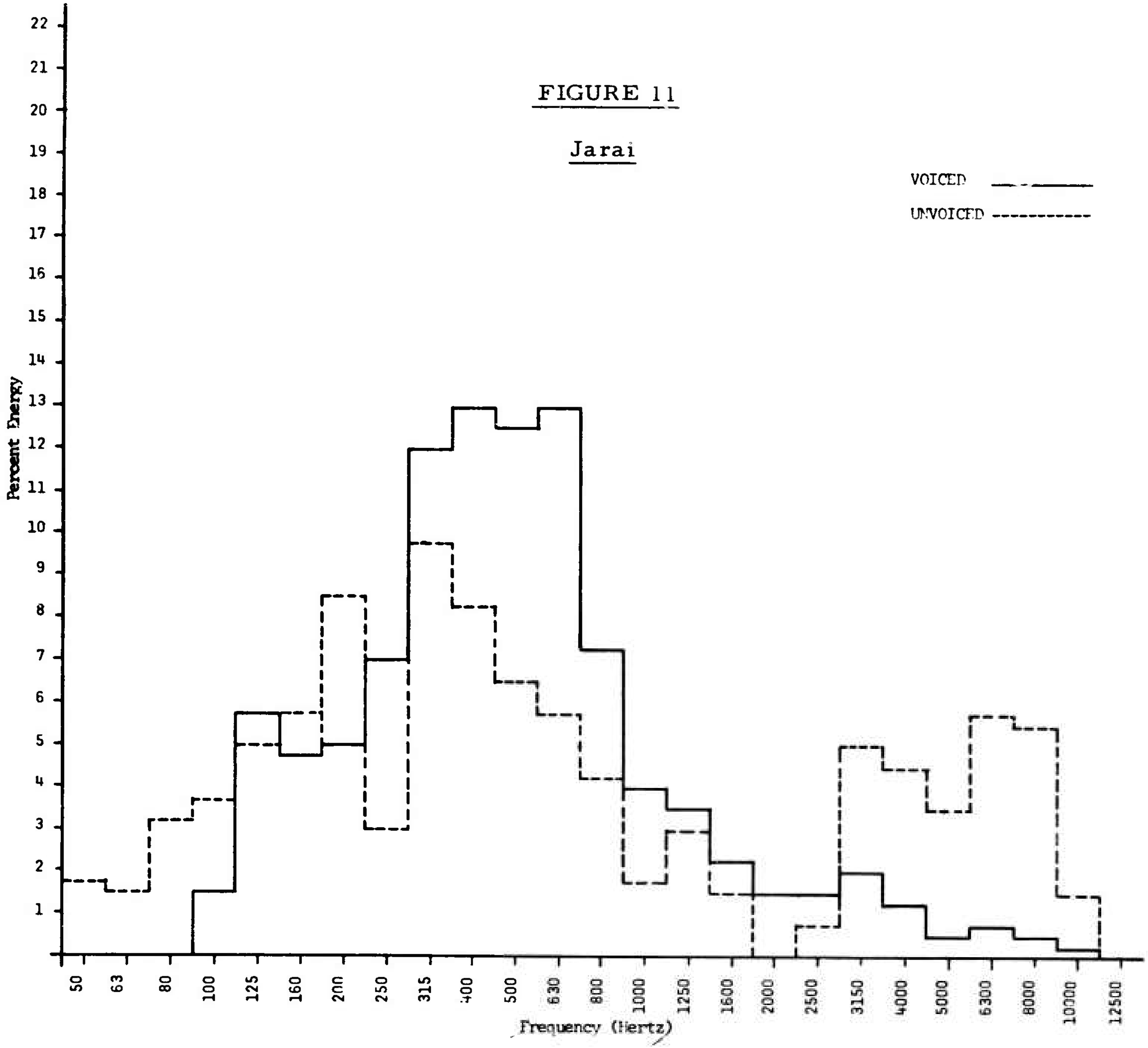


FIGURE 11

Jarai



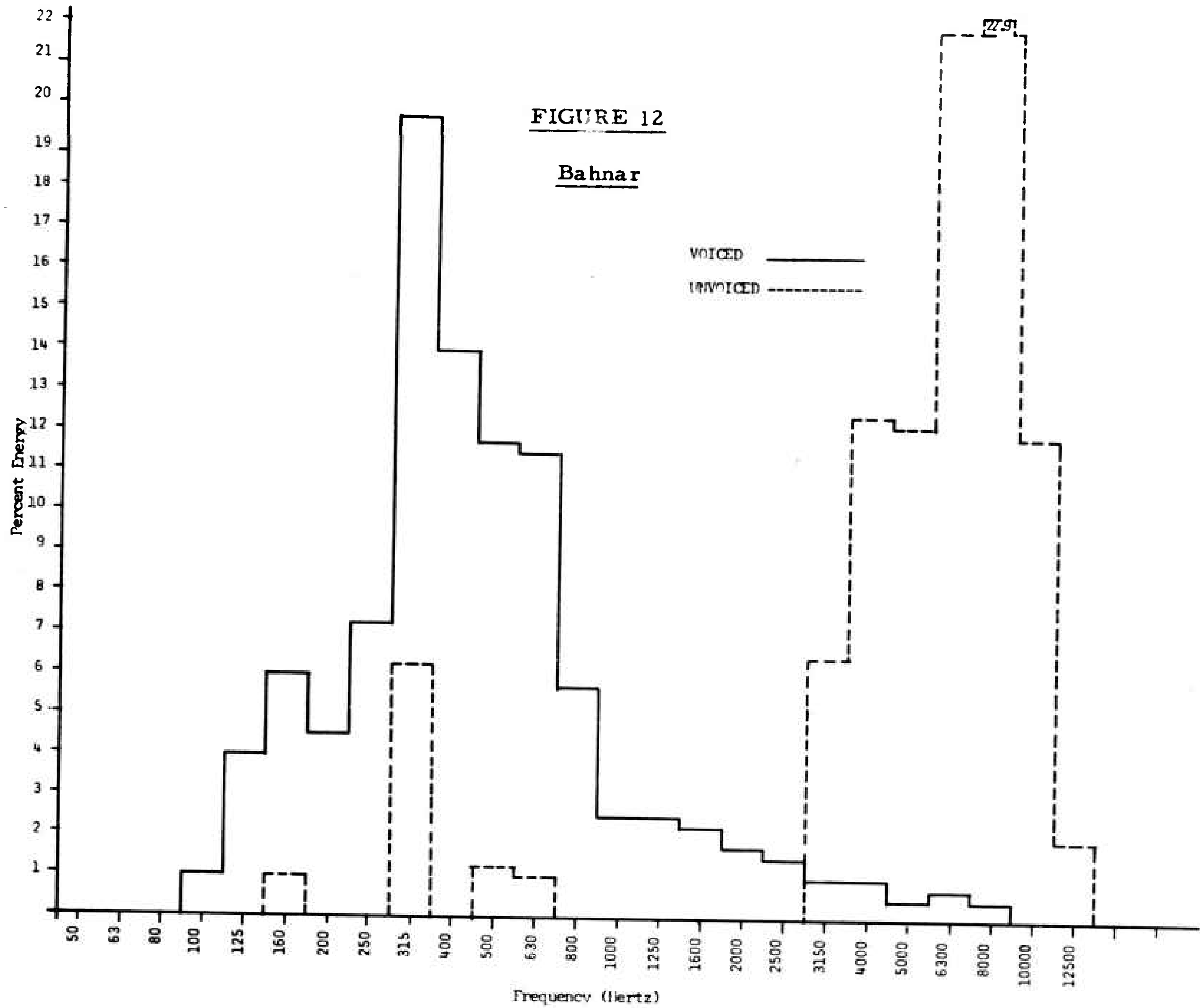


FIGURE 12

Bahnar

FIGURE 13

Sedang

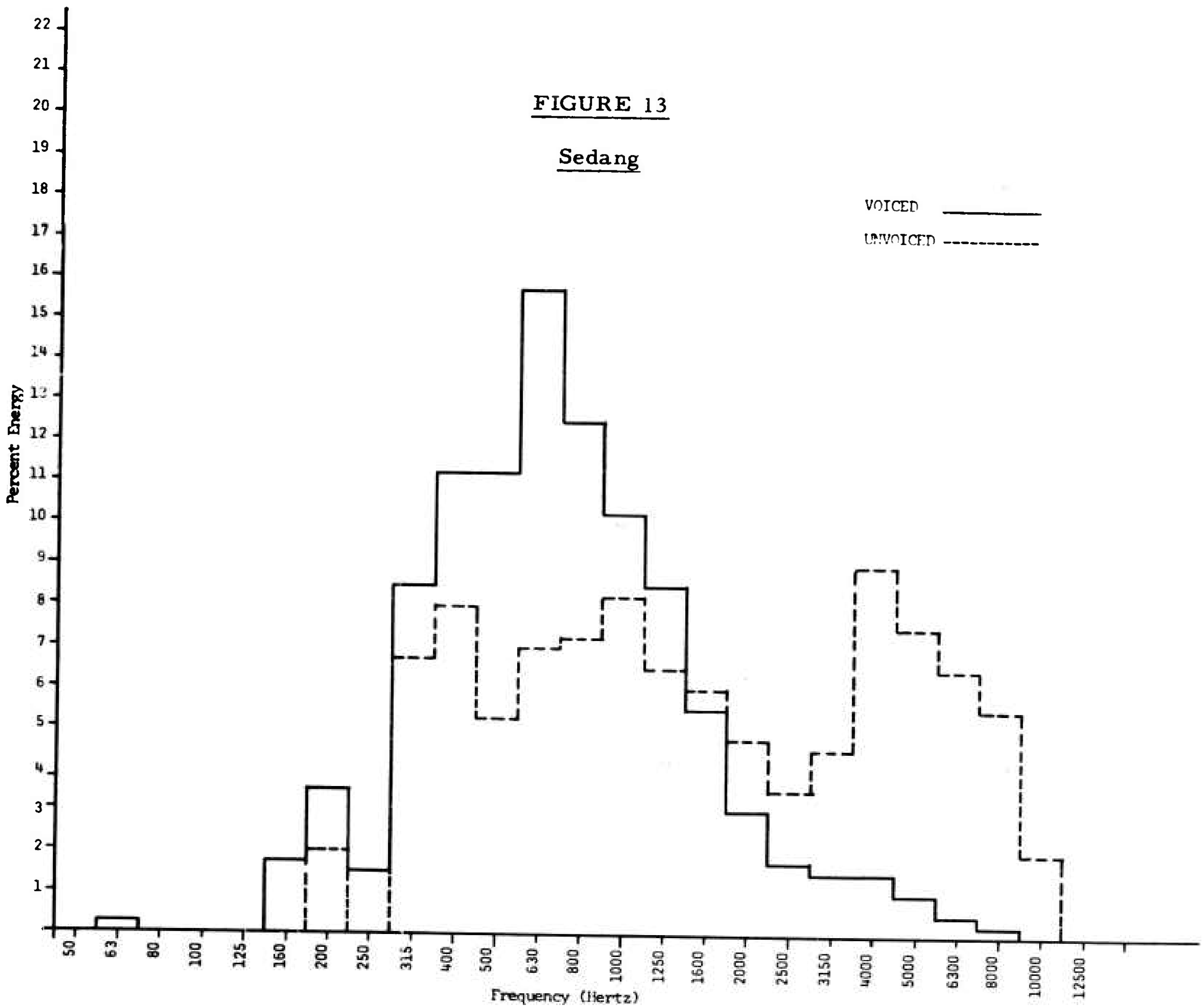
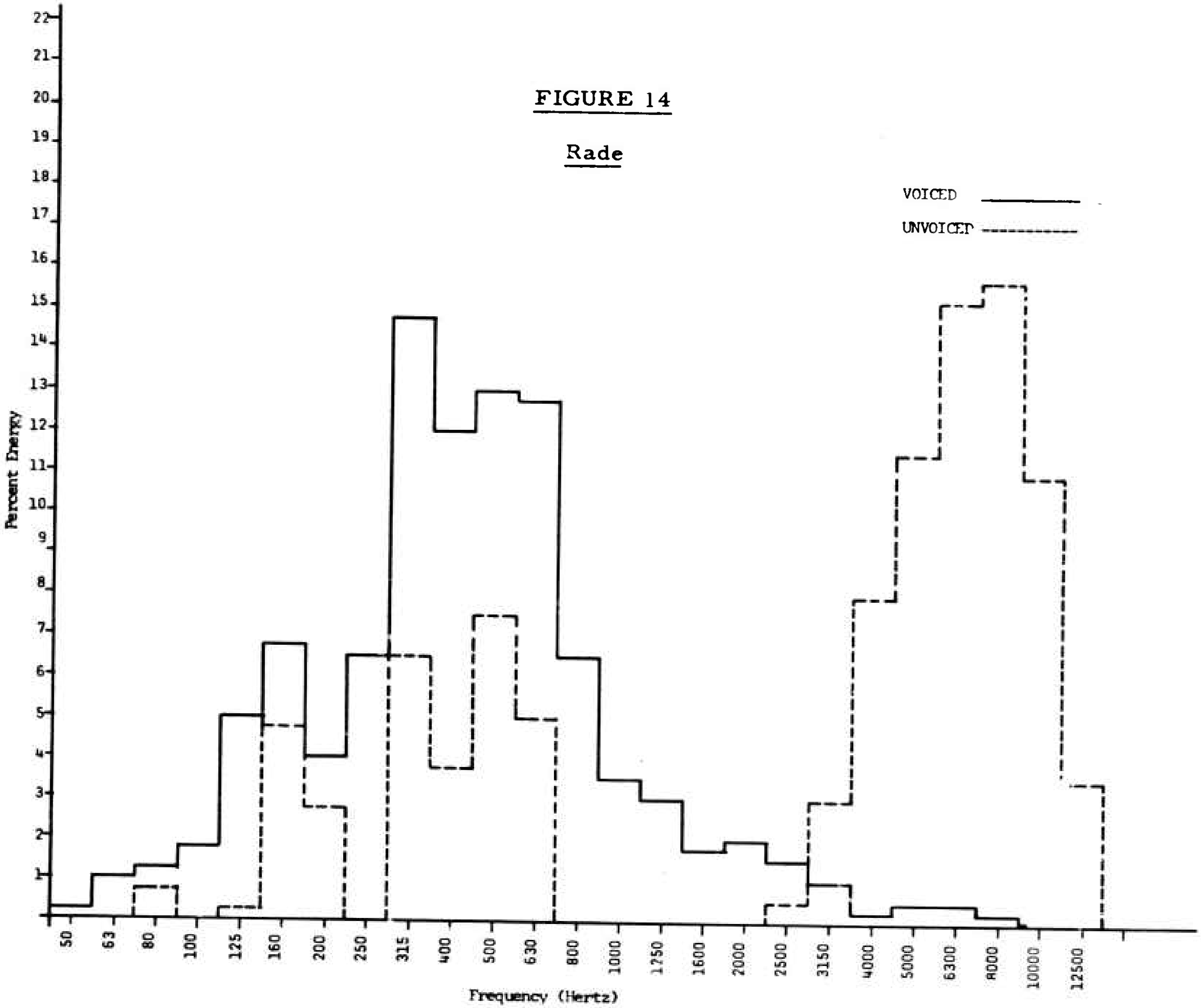


FIGURE 14

Rade



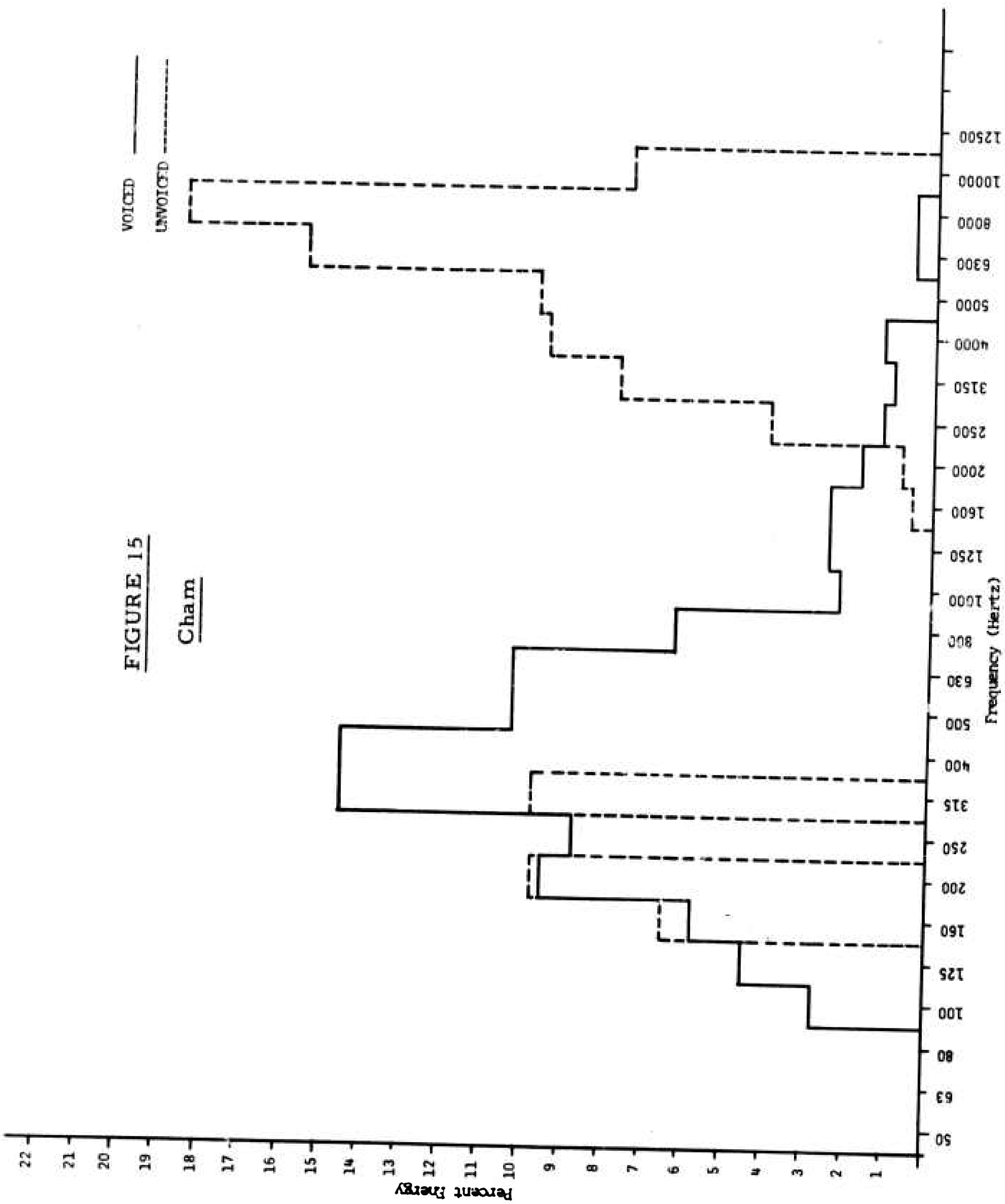
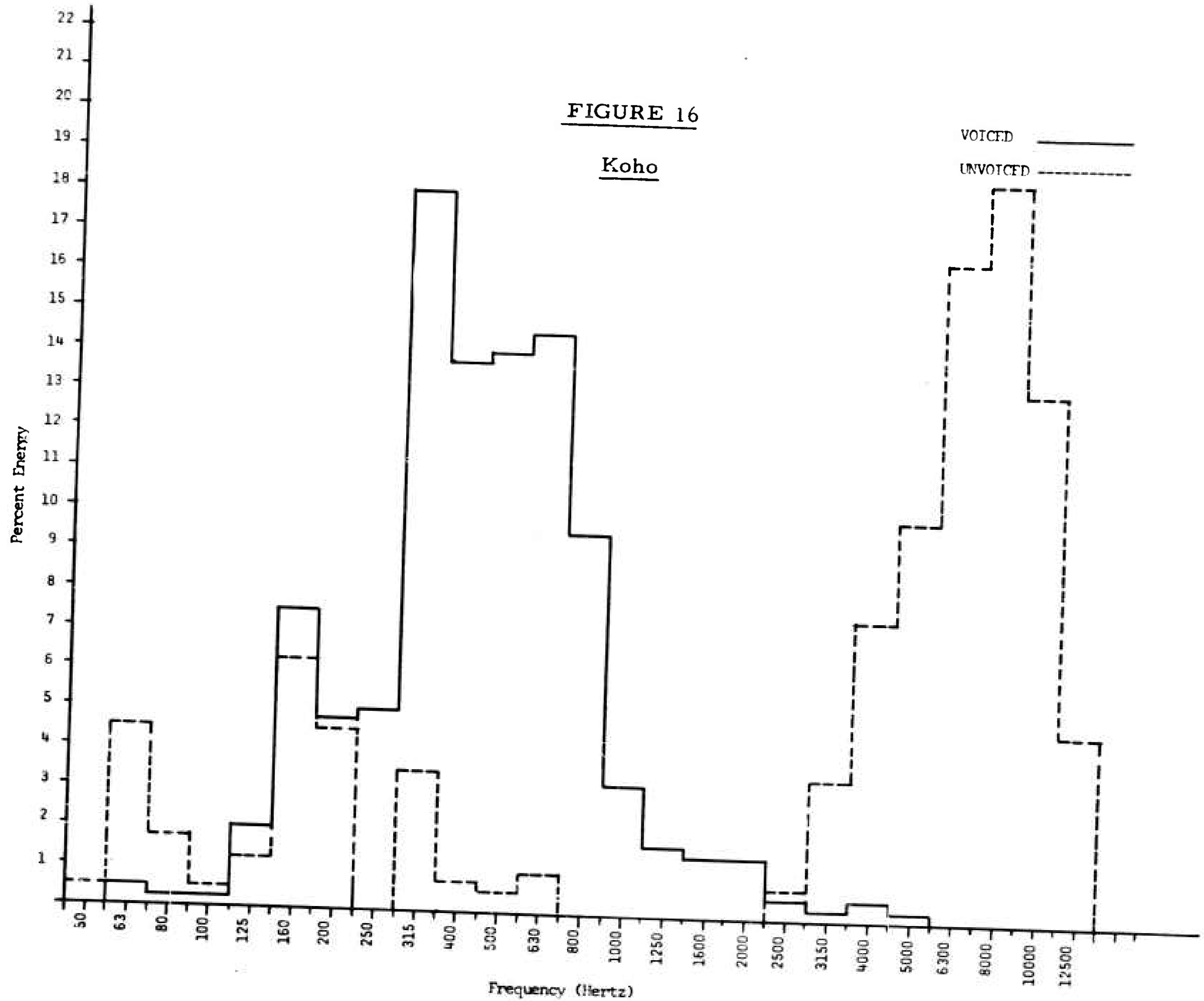


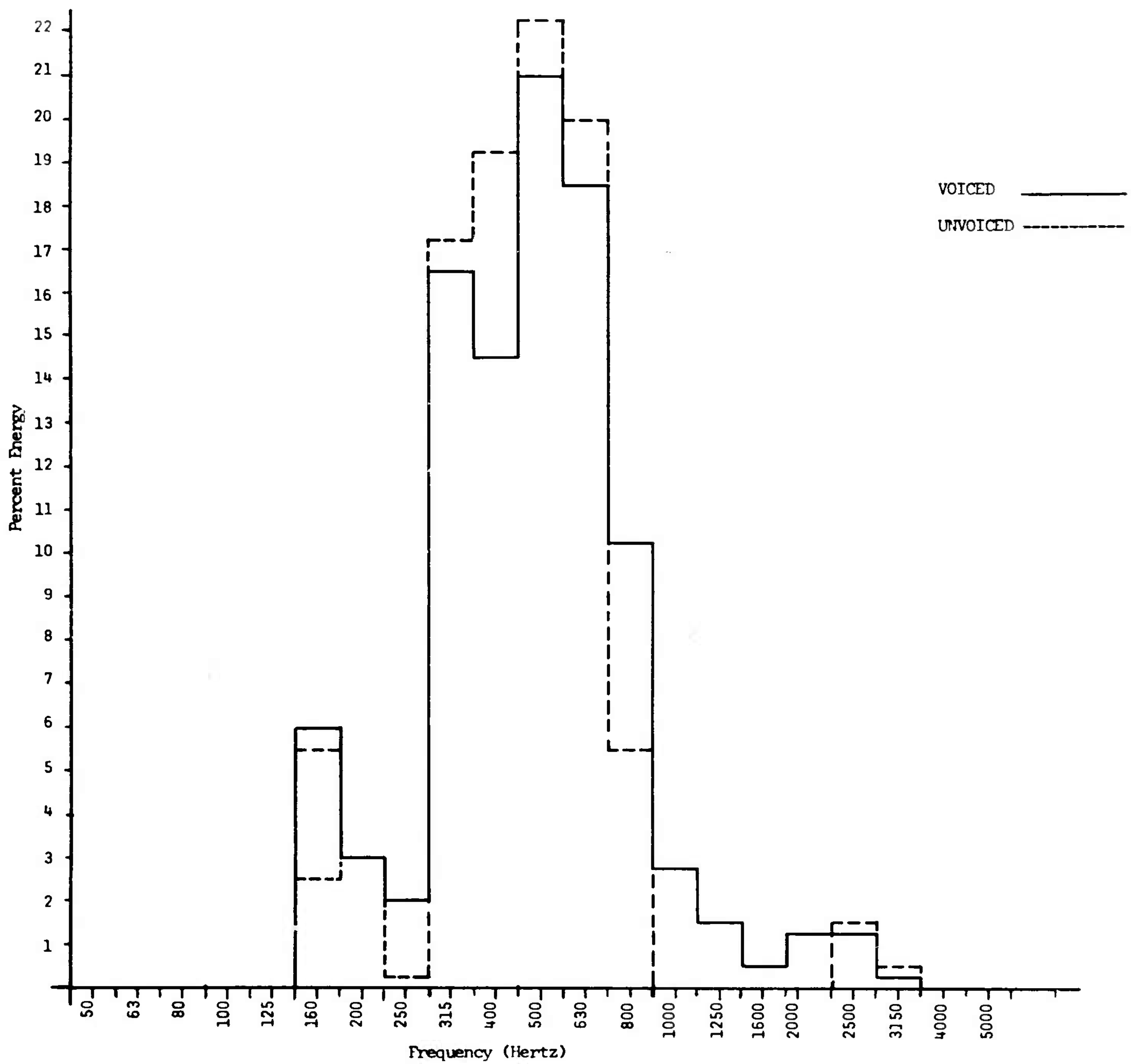
FIGURE 15

Cham

FIGURE 16

Koho




VOICED
UNVOICED
Percent Energy
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
Frequency (Hertz)

WAVE PATH PHYSIOGRAPHY

GENERAL

The effects of terrain upon both HF and VHF radio communication have been the subject of detailed study and measurement for many years. In studies of this nature, typically a specific element becomes the variable (vegetation, frequency, radio type, or soil) while the other elements in the experiment are carefully instrumented, measured and documented so that they become, for the purposes of the experiment, constants. The effects of the various physical elements of the terrain upon radio wave paths may thus be isolated and studied.

In the wave path physiography study, however, the cumulative effects of the terrain, or more specifically the physical environment, are studied as a complete system including the tactical situation and the actions and reactions of the user. He uses a standard military radio, subject to the wear and tear of numerous tactical missions, not a specially-calibrated test instrument, and finally, his communications are subject to the combined effects of topography, vegetation, soils and weather. The end result of this is, in essence, "communications yes or no, from where to where, with what radio and with what frequency." Much additional data are gathered, as has been explained elsewhere in this report, and shown in more detail in Appendix A, but the data listed above form the basis of the physiographic wave path analysis study.

MIXED PATH ANALYSIS

With the exception of some deserts, oceans, and ice-caps, very little of the earth's surface is completely homogeneous. Any given communication therefore will travel over topography of differing configurations, vegetation of differing species and types, and soils and rocks of differing physical characteristics. In Vietnam, for example, the same communication may, in 10 kilometers or less, travel over saturated rice paddies, a town, a coconut plantation, a seawater inlet, and a mangrove swamp. In the basic recorded data these various physical elements are represented only as having a cumulative effect on the communication examined. The purpose of the wave path physiography task is to isolate, as far as practical, the separate effects of the differing elements of the physical environment in such a mixed path. Thus, the relative importance of these elements may be placed in the proper context in subsequent research. For example, the Defense Research Corporation (DRC) has prepared a detailed tactical communications simulation. Even though a computer of large capacity is used, the problem of mixed path physiography analysis

was not undertaken because of its complexity and lack of verified input data*.

TOPOGRAPHY

A detailed analysis** is made of the topography between base and patrol, as reported by the UTM locations of each terminus. Range is computed, based on these locations. As many as six different card fields may be used to describe the slope (roughness) of the topography, the presence or absence of hydrographic features (river, stream, canal, lake), the salinity or acidity of hydrographic features encountered, and the presence or absence of culture features such as towns, military camps or airfields. Topography and weather data reported on the original data sheet from base and patrol complete the physiographic record. Together with the data transferred from the basic data card, including contact success or failure and type of radio transmission (VHF or HF), this completes the record of one line item of topographic data.

TERRAIN MASK

The problem of intervening terrain masks in VHF communications required further investigation in this task. Although the general assumptions prevailed that VHF followed line of sight between two terminals which required mutual radio intervisibility, the work of earlier researchers and the observations of television signals which reach shadowed areas, indicated that the line of sight rule had flexibility which should be further examined. Data developed by Jansky and Bailey*** and others, and further predicted by the Defense Research Corporation, also indicated that terrain masking did not always mean communications loss.

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*C. T. Clark, et al, Computer Simulation of CI Tactical Operations and Communications, Santa Barbara, California: Defense Research Corporation, October 1966.

**A geographer, using the AMS L:50,000 maps (L 7014-1965/66 edition) plots each location and examines the wave path by sector.

***Tropical Propagation Research, Semiannual Report No. 7, U.S. Army Electronics Command, Fort Monmouth, New Jersey: Jansky and Bailey, Research and Engineering Division. Signal Corps Contract DA 36-039 SC-90889.

In Vietnam this was spectacularly demonstrated during a visit to the 1st Australian Task Force (1 ATF) in which VHF communications were successful over a steep wooded range of hills, masking from 1,000 to 1,500 feet over a range of 18 kilometers. Even more startling results were observed in which the Long Range Reconnaissance Patrol (LRRP) of the 1st Brigade, 101st Airborne Division (1/101), communicated regularly to a range of 52.4 kilometers using AN/PRC-25 radios over terrain in which three distinct ridge lines intervened and blocked the profile. Although an RC-292 antenna is usually employed at each terminal, communications of acceptable quality were demonstrated to the study group over this range using the standard long whip antenna.

Terrain mask, therefore, required analysis as an element of the wave path physiography program. Accordingly, all the Vietnamese communications using the AN/PRC-10 or other VHF sets are examined on large scale topographic maps for presence or absence of terrain masks. This is done by the hasty profile method. If a mask or masks exist a topographic mask analysis card is prepared as shown in Appendix A. At this point in the analysis effort, 161 successful Vietnamese VHF communications have been recorded over terrain masks.

VEGETATION

The same communication is then examined from the point of view of vegetation. Again, the wave path may be divided into six segments to cover the majority of mixed path cases. Vegetation is described as to species, density and presence or absence of clearings or open areas. The wave path as a whole is described as to vegetation masks which may exist. From the original data cards, vegetation as reported at base and patrol is reported and coded.

The division of the wave path into segments on the basis of vegetation may or may not represent the same divisions as for topography. (Coding system is shown in Appendix A.)

SURFACE AND SUBSURFACE MATERIALS

The presence of surface materials (soils) are coded in five fields, and are based upon both examinations of a large scale topographic map and a special soils map of Vietnam*. The division of the wave

*Moormann, I.R., The Soils of the Republic of Vietnam, Republic of Vietnam, Ministry of Agriculture: Saigon, 1961.

path into these five segments may or may not coincide with the topographic or vegetation divisions of the path. These physical characteristics of soils vary with the state of saturation and other factors. The soil saturation, therefore, is shown on the punch cards by segment of wave path examined.

Rock types are coded in four fields, based upon a series of French geological maps surveyed prior to World War II. Although the basic data are quite general in nature, they reflect the nature of surface outcroppings and subsurface geologic structure in sufficient detail that their physical properties may be taken into account from the point of view of their effects on HF communications.

Surface and subsurface materials are recorded upon the same punch card; details of the coding are shown in Appendix A.

PRELIMINARY PHYSIOGRAPHIC DATA ANALYSIS

GEOGRAPHIC DISTRIBUTION OF THE DATA

Geographic distribution of the data collected from the Vietnamese tactical units has been shown in Figure 1 (page 5). From this it may be observed that a reasonable spread of the data throughout Vietnam has been accomplished, bounded by the level of tactical activity which has occurred in the major terrain regions.

The physiographic data analysis and coding task has followed the basic data collection program and has been underway since 1 December 1966, using a staff of three Thai geographers. Results of the data coding reduction and coding effort to date are shown in Table 11.

Comments on Table 11

1. Cards are now being prepared from these coded line items. Range and topographic data are presented on the same punch card. Rock types and soil are presented on the same punch card.

2. UTM grid references are shown in Figure 18. Zones XS, WS, WR and XT lie primarily in delta terrain in which no topographic coding is necessary and few rock exposures are present.

3. Terrain regions are from Figure 19, compiled from the second Semiannual Report and repeated here for reference.

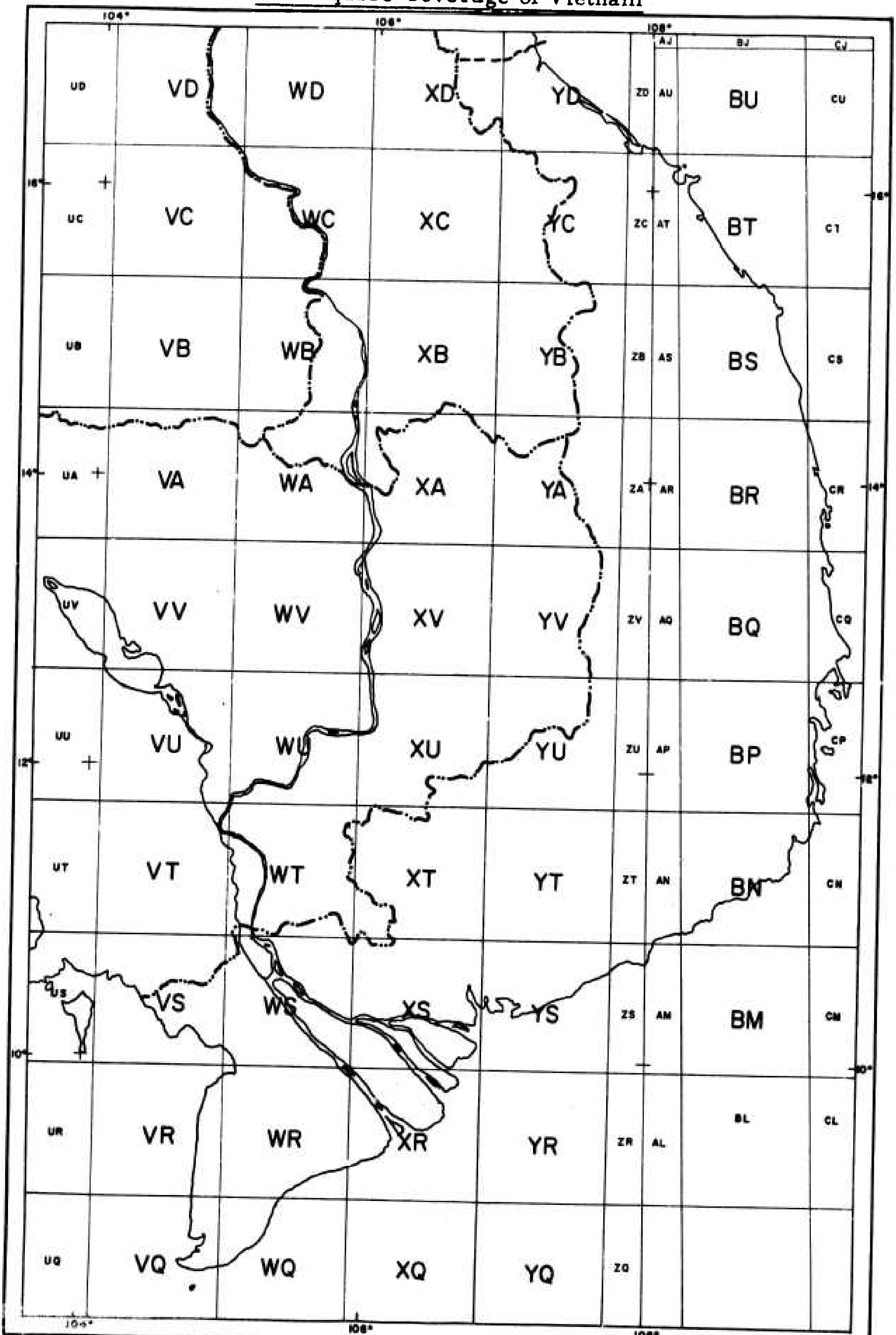
TABLE 11

Physiographic Coding Program Status - Vietnamese Forces Data
15 January 1967
Patrol Data Only

Letter Zone of Communication Organization	Range Calculations Completed	Topographic Coding	Terrain Mask Analysis	Vegetation Coding	Soils Coding	Rock Types Coding	Terrain Region
AN	6	-	-	21	21	21	Vb/Vc
AR	6	6	13	6	6	6	IIIa/IVa
AT	3	3	11	0	0	0	IVa/Vc
BN	25	8	7	0	0	0	Vb/Vc
BP	44	7	-	0	0	0	IVb/Vc
BQ	7	-	-	-	-	-	IVb/Vc
BR	13	13	4	11	11	11	IVb/Vc
BS	19	19	-	0	0	-	IVa/Vc
BT	18	31	9	0	0	-	Vc
CP	43	15	15	0	0	-	Vc/Va
CQ	29	36	32	44	44	44	Vc/Va
XS	853	878	0	849	899	0	Ia/Ib
XT	173	135	35	140	140	0	Ia/IIb
WR	25	110	0	40	40	0	Ia/Ic
WS	132	287	28	287	287	0	Ia/Ic
YS	13	0	0	0	40	40	Ia/Ib
ZT	9	0	8	16	16	16	Ia/Ic/Vb
YD	20	0	5	20	20	20	IVb/Vb
XR	20	0	-	-	-	-	IVa/Vb/Vc
Total	1,458	1,548	167	1,434	1,524	158	

FIGURE 18

Index of Universal Transverse Mercator (UTM) Grid Square Coverage of Vietnam



Since an acceptable geographic distribution of basic data has been received in both base and patrol communications, geographic samplings are now possible in most of the major terrain regions.

PRELIMINARY RANGE CALCULATIONS

A basic element of the physiographic wave path analysis task is the calculation of ranges. Based on the UTM coordinate locations reported by base and patrol, pythagorean calculations are made for the range. Range data prepared at this time (the program is a continuing one) are presented in Figures 20 through 25. Once the topographic data cards are punched, range data will be readily available for machine analysis and subsequent correlation with both the patrol communications task and the physiographic wave path analysis task.

Data presented in these figures represent a first manual analysis of the range data which is being placed on punch cards for more detailed machine analysis at this writing. The total sample of Vietnamese patrol to base communications calculated is 1,458. VHF radios generating the range data include the AN/PRC-10, AN/PRC-6, AN/PRC-25 and the TR-20. HF radios include the AN/GRC-9, AN/GRC-87 and the naval TCS series (see Table 1).

The current state of the range data makes breakdown by individual radio type impractical. Ranges have been manually grouped in significant elements of distribution--more detailed breakout of ranges by radio type and terrain region will follow as the mechanization of the data base proceeds. Likewise, appropriate correlation with data of the type shown in Tables 2 through 8 of this report, will be possible once mechanized data analysis is underway.

It is important to note that the ranges reported in these figures represent user ranges, and do not represent maximum ranges of the sets either under test conditions or in the various terrain regions of Vietnam. They do, however, represent a logical range distribution in the different areas of the country, representing ranges actually employed by the users in tactical situations. The sample in the highland and high plateaus region is presented only as a matter of information. At this writing, insufficient communications from this area have been coded and analyzed.

An examination of Figures 20 through 25 show the following information which may be of significance from even this preliminary analysis:

1. Throughout Vietnam 68 percent of Vietnamese VHF communications are 5 kilometers or less.

FIGURE 19


NORTH VIETNAM
LAOS
CAMBODIA
SOUTH
CHINA
SEA
COASTAL
LOWLANDS
AND
HILLS
INTERIOR
HIGHLANDS
HIGH
PLATEAUS
TERRACES
DELTA
HUE
DANANG
QUANG NGAI
KONTUM
PLEIKU
QUI NHON
TUY HOA
BAN ME THUOT
NHA TRANG
(CAM RANH BAY)
TAY NINH
(PLAIN OF REEDS)
SAIGON
MY THO
(SAIGON DELTA)
VUNG TAU (CAP St. JACQUES)
CAN THO
BAC LIEU
QUAN LONG
(CAMAU PENINSULA)
(MOUTHS OF THE MEKONG)
PHU QUOC ISLAND (VIETNAM)
ZONE "D"
PHYSIOGRAPHIC PROVINCES OF THE REPUBLIC OF VIETNAM
SCALE
100 50 10 0 100 KM
INTERNATIONAL BOUNDARY
PHYSIOGRAPHIC PROVINCE BOUNDARY
SIGNIFICANT PHYSIOGRAPHIC FEATURES AND LOCATIONS INDICATED ( )

Figure 19 Continued

Physiographic Province and Region		Regional Description
I Delta		
Ia	Ricelands	Flat, seasonally to permanently innundated. Ricelands cut by numerous canals and ditches with local areas of dry crops and coconut plantations, plus undeveloped marsh and swamp. Paddy flooding 6-18 inches, mature rice grows to 36-48 inches. Tidal influences strong on major canals. Rice sowed June-July, harvested November-December. Paddies driest in April.
Ib	Plain of Reeds and similar terrain	Flat, uncultivated area, innundated but covered by heavy reed, heights of 3 ft to 7 ft but locally may reach 12 ft. Water brackish to highly acidic in dry season, as evaporation concentrates chemicals in solution. Some small inclusions of rice as in Ia above.
Ic	Mangrove	Dense growth of trees and brush, becoming more dense as coast is approached. Heights of trees and brush 6- to 75 ft, very dense canopy. Several species all characterized by dense canopy and interlocking above-ground root structure. Diurnal salt water tidal flooding. Tidal ranges locally approach 15 ft.
Id	Coastal swamp forest (non-mangrove)	Heavy growth of salt water tolerant trees and brush, slightly less dense and lower than mangrove. "U-Minh" forest, north of Ca Mau typifies region. Cajaput forest locally known as "Tran" type, characterized by heights to 60 ft, trunks spaced to 12 ft allowing greater freedom of movement. Continuous overhead canopy.
II Terraces		
IIa	Evergreen Forest	Broadleaf evergreen forest, typified by "Zone D" primary and secondary jungle, dense undergrowth, particularly in secondary jungle area. Some swamp, abandoned and active rubber plantations. Major river (Dong Nai) and several tributaries cut region. Some rice in Northwest region near Tay Ninh.
IIb	Rubber plantation mixed with primary and secondary evergreen forest	Numerous active and abandoned rubber plantations, particularly on North/South axis from Saigon to Cambodian border. Heavy undergrowth in abandoned plantations, active plantations relatively clear. Some abandoned plantations have reverted to secondary jungle, brush or bamboo. Active rubber plantation areas on East/West axis from Bien Hoa include many dry crop fields and young seedling rubber trees.

Figure 19 Continued

Physiographic Province and Region	Regional Description
III High Plateaus	
IIIa Darlac-Kontum Plateaus	Undulating terrain, primarily grassland to 5 ft, scrub, bamboo secondary jungle with pockets of primary jungle. Isolated volcanic hills and mountains, relative relief to more than 2,000 ft. Area flanked by high jungle-covered mountains on the West and by the interior highlands. Extensive tea and coffee plantations in Ban Me Thuot area. Grassland burned in March-April period.
IIIb Lam Dong, Dalat Plateaus	Rolling terrain flanked by low hills, relative relief 1,000 ft or less. Extensive dry crop cultivation, some rubber in Lam Dong Province. Tea cultivation in Lam Dong and "European vegetables" in Dalat area are major crops. Pockets of swamp in poorly-drained areas of Lam Dong Plateau. Patches of primary and secondary jungle in vicinity of Dalat, many clearings as "ray" cultivation is active in region.
IV Interior Highlands	
IVa Northern mountains region	High jungle-covered, steep-sided mountains, altitudes locally to excess of 7,000 ft, relief to deep valleys, few routes of movement. Dense evergreen jungle covers most of slopes although local "ray" clearings exist. Some clearings overgrown with second growth jungle, "elephant grass" up to 15 ft tall, or bamboo.
IVb Central mountains region	High rugged mountains, separated by wide valleys and basins. Rolling foothills and upland valleys. "Ray", dry crop cultivation plus limited commercial logging. Many abandoned ray and logged clearings, some overgrown. Scattered rice in lower valleys.
V Coastal Lowlands and Hills	
Va Dunes and dune-ridges with beaches	Long beaches, sand flats and dunes, and high dune ridges to 500 ft front much of the coast, particularly prominent in Da Nang, Qui Nhon, Cam Ranh, and Phan Thiet areas. Some lightly vegetated dry coastal plains similar to Region Vc.
Vb Coastal hills and ridges	Varied topography and vegetation. Hills are spurs of inland mountains and range to 2,500 ft altitude, seaward extensions in steep rugged cliffs or low rounded hills fronted by narrow coastal plains or beaches. Vegetation from secondary jungle with upland clearings to rice and dry crops in the coastal plains. Some hills almost barren and support only light scrub.
Vc Coastal and inland valleys	Large alluvial valleys, typically deltaic opening toward sea. Rice primary crop, some dry crop and some marsh near river estuaries. Soil coarsens inland and rice gives way to dry crops and plantations. Some plains very dry and almost arid as they lie in "rain shadow" between inland mountains and coast.

FIGURE 20

Country-Wide Range Distribution for Vietnamese Patrol and Small Unit VHF Radio Communications

860 Communications Examined

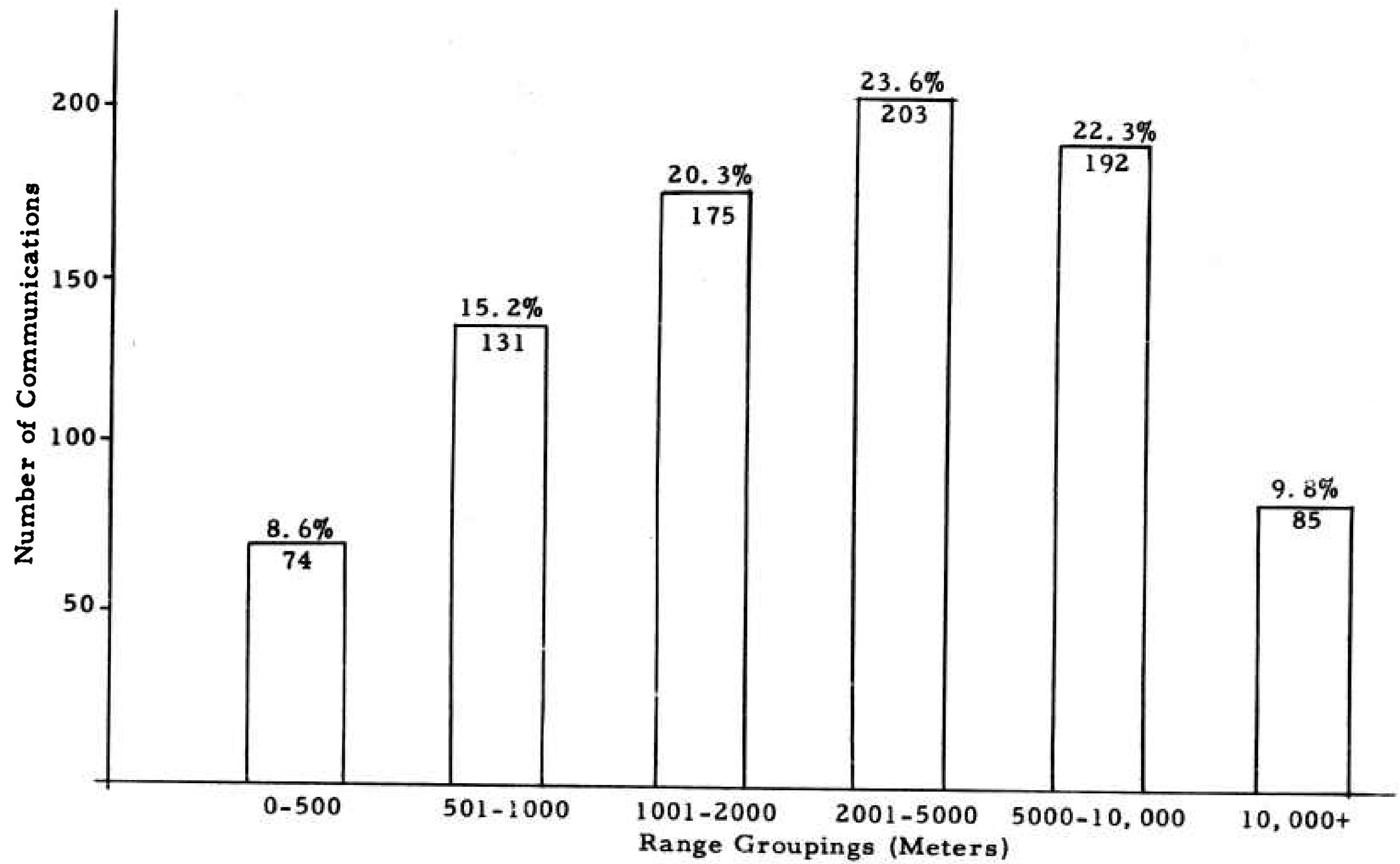


FIGURE 21

Country-Wide Range Distribution for Vietnamese Patrol and Small Unit HF Radio Communications

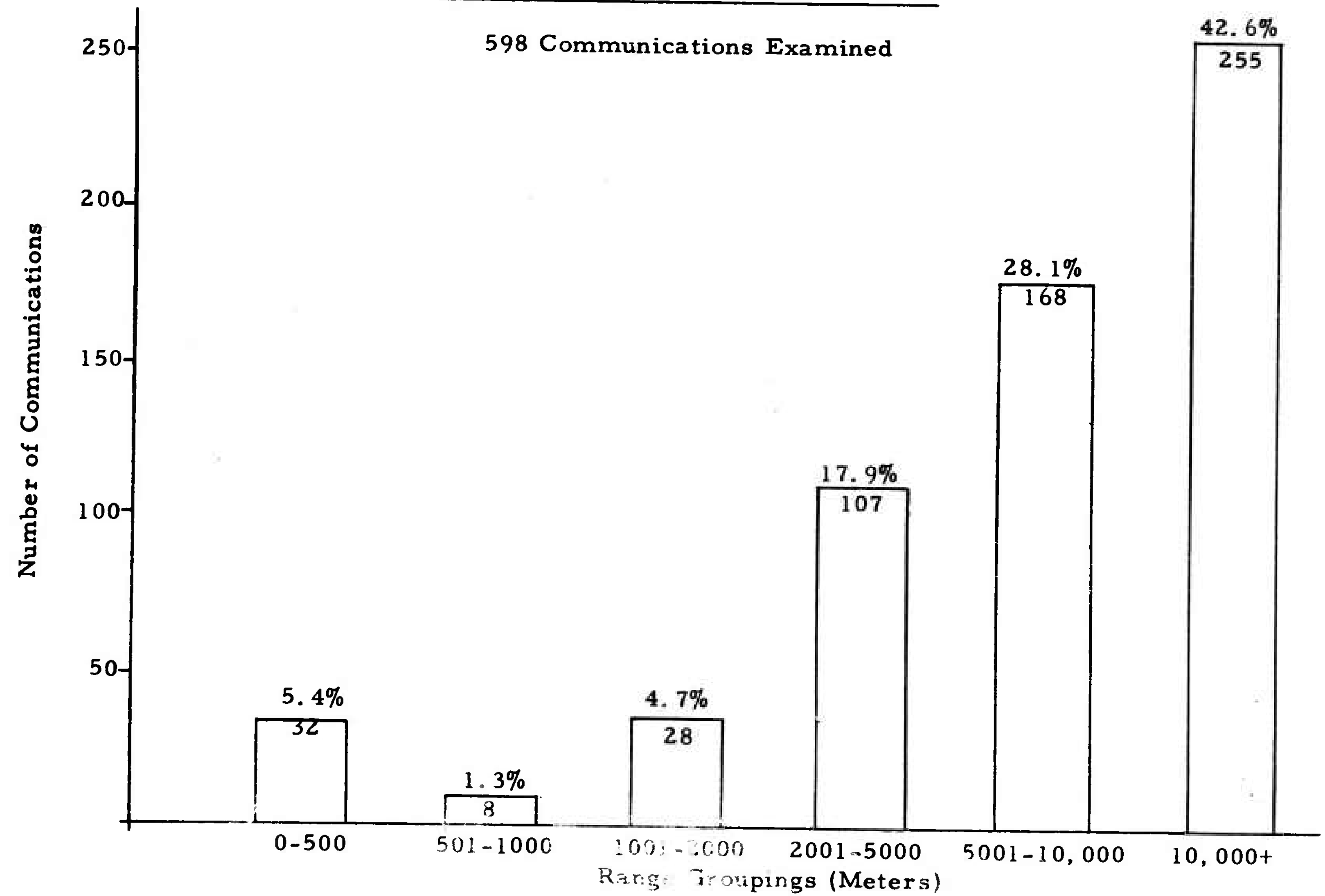


FIGURE 22

Range Distribution for Vietnamese Patrol and Small Unit VHF Communications
Mekong Delta Region

522 Communications Examined

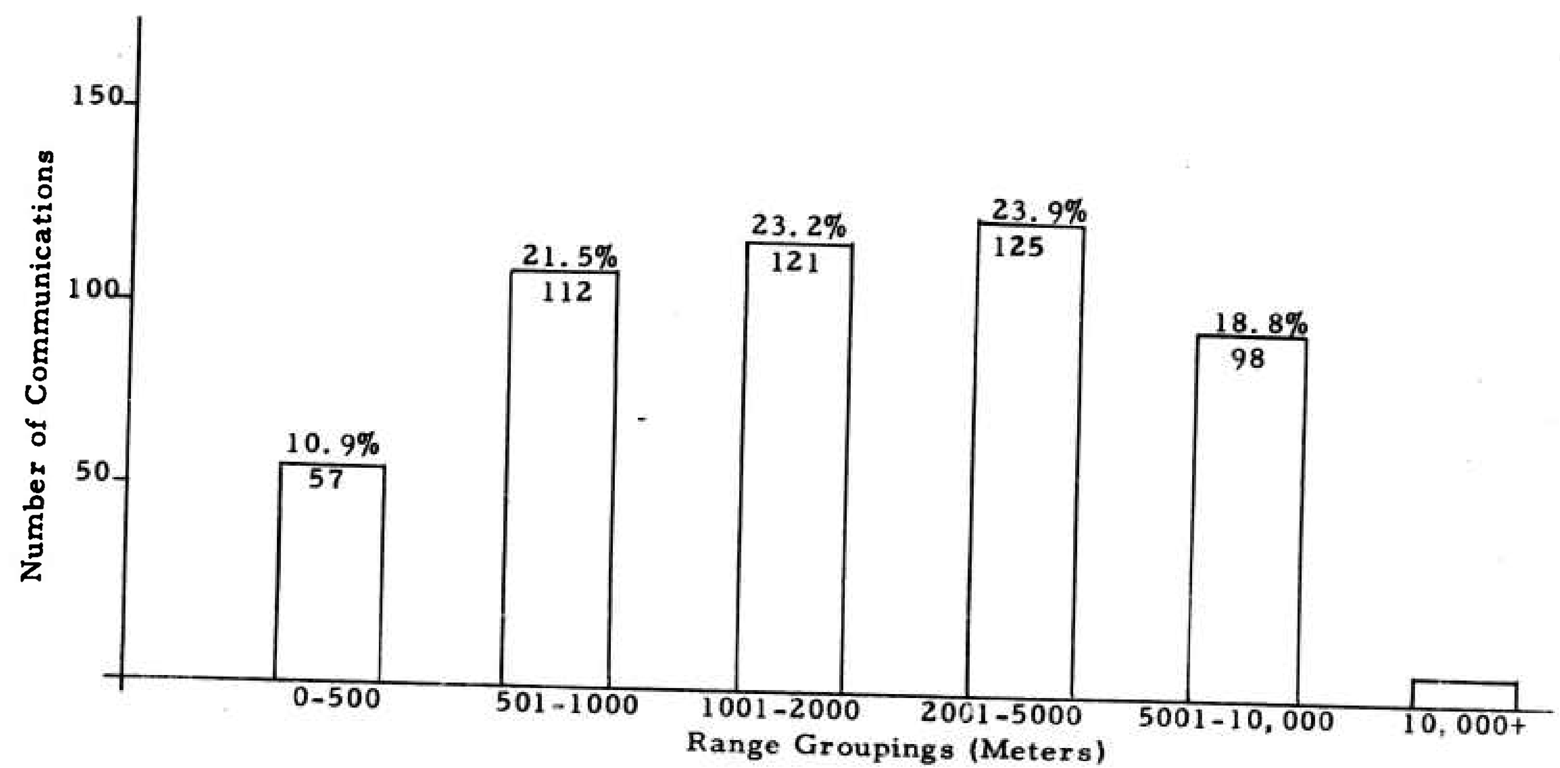


FIGURE 23

Range Distribution for Vietnamese Patrol and Small Unit VHF Communications Central Terrace Region

145 Communications Examined

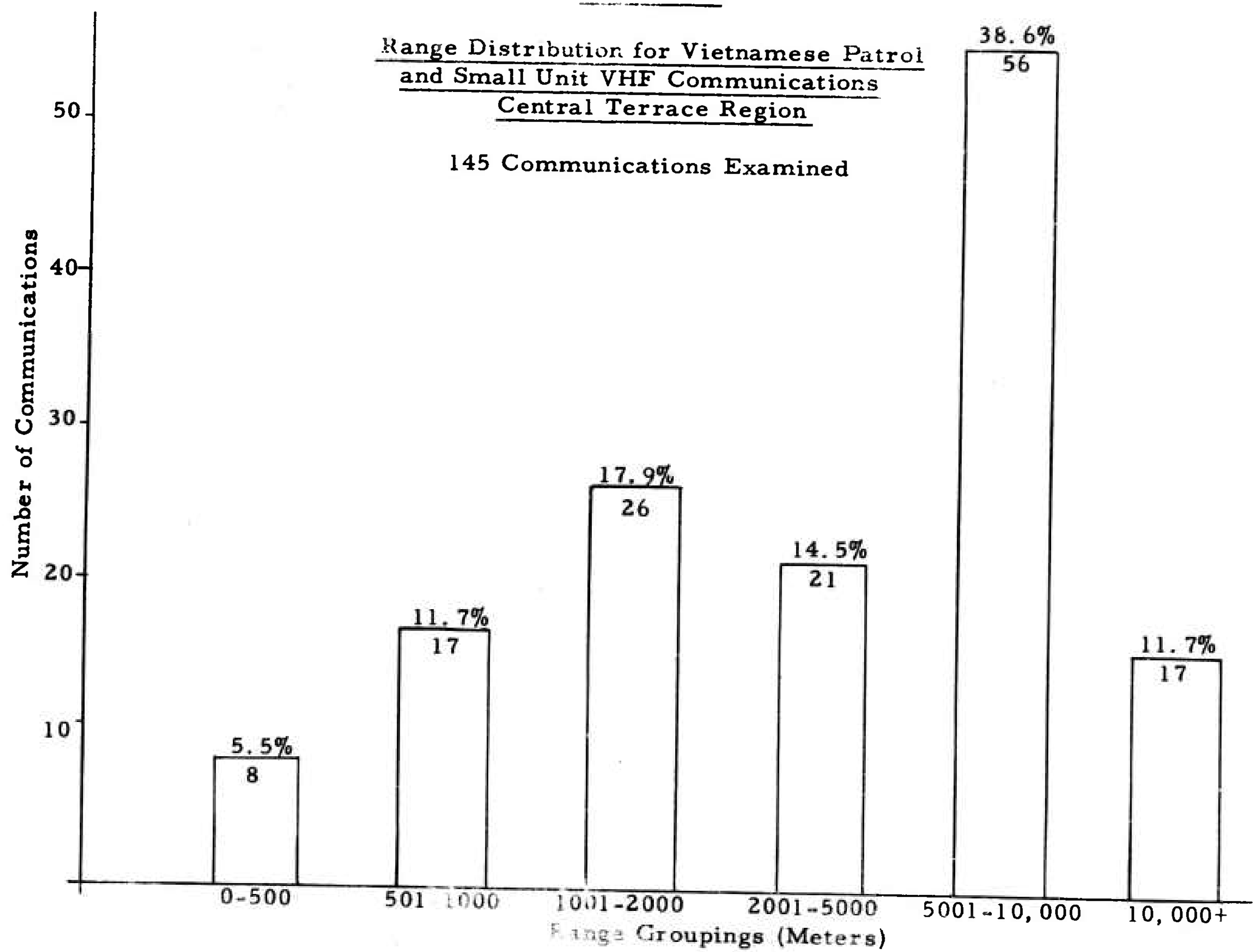
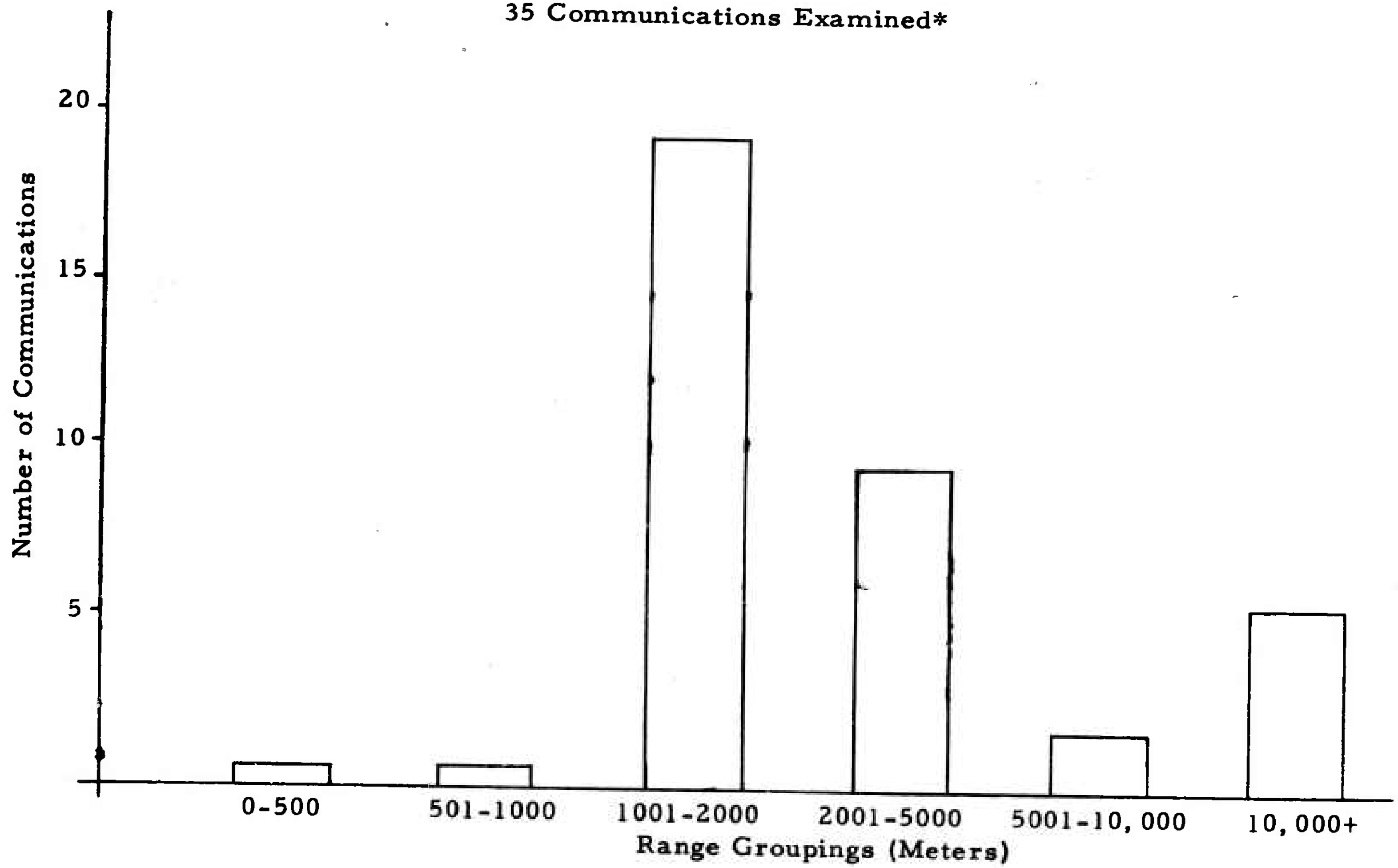


FIGURE 24

Range Distribution for Vietnamese Patrol and and Small Unit Communications Using VHF Radios, High Plateaus and Interior Highlands Region

35 Communications Examined*

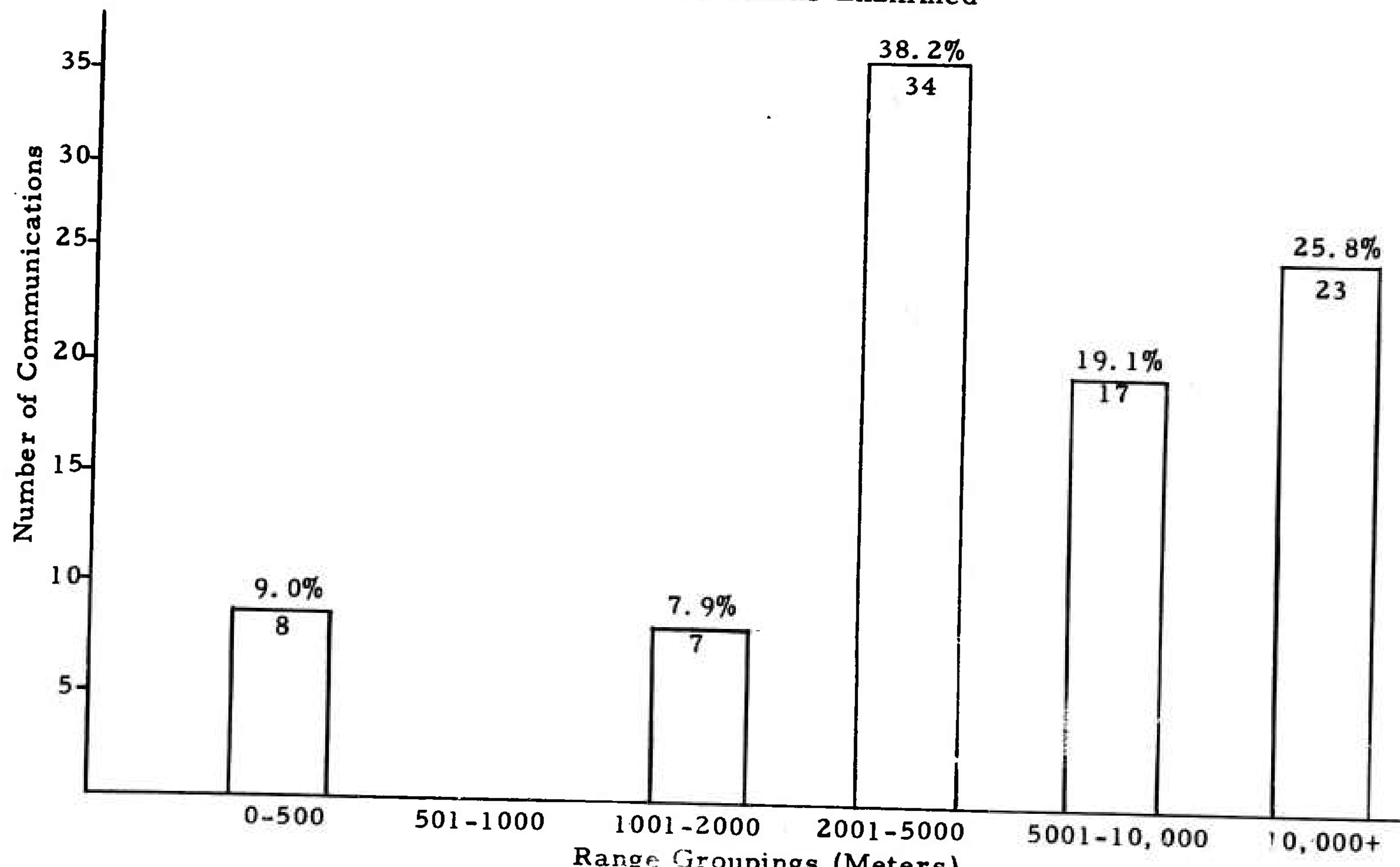


*Presented as matter of information only. Analysis is continuing.

FIGURE 25

Range Distribution for Vietnamese Patrol and Small Unit Communications Using VHF Radios - Coastal Lowlands and Hills Region

89 Communications Examined



2. Throughout Vietnam 61 percent of the Vietnamese HF communications are in excess of 5 kilometers.

3. In the Mekong Delta region, 80 percent of the Vietnamese VHF communications are 5 kilometers or less.

4. A higher percentage of Vietnamese communications in excess of 10 kilometers are reported from the Coastal Lowlands and Hills physiographic province than elsewhere in Vietnam. This maywell be caused by the presence of extensive areas of cleared high ground in this region, allowing good point to point communication across the valleys and/or the gradually rising ground inland which allow communications down the axes of the valleys and lowlands.

NON-LINE OF SIGHT COMMUNICATIONS PRACTICES AMONG U.S. AND ALLIED UNITS

GENERAL

In the second phase of the study commencing in the fall of 1966, many U.S. and allied units were visited. See Table 9 and Figure B-1*. These units were equipped with AN/PRC-25 and AN/VRC-46 radios which are more modern and more powerful than the AN/PRC-10 of the Vietnamese forces. With this equipment, numerous communications were observed over terrain masks, some of formidable magnitude, which would logically be expected to completely block VHF radio communications. Although the condition was first considered to be a "freak situation" as more units were visited it was noted that non-profiling communications were accepted as a regular capability and not as an intermittent phenomenon. Although data sheets have not been analyzed from these units, observations made by the study team during the past four or five months have indicated that this anomaly does in fact exist throughout hilly and mountainous areas of Vietnam and therefore warrants further investigation. This is being pursued through the path physiography task. In the paragraphs below, two case studies are reported as noted by the field team.

1st AUSTRALIAN TASK FORCE (Figure 26)

This brigade-sized unit is located in a rubber plantation approximately 70 kilometers southeast of Saigon in Phuoc Tuy Province. The brigade headquarters and tactical battalions are located in a rubber

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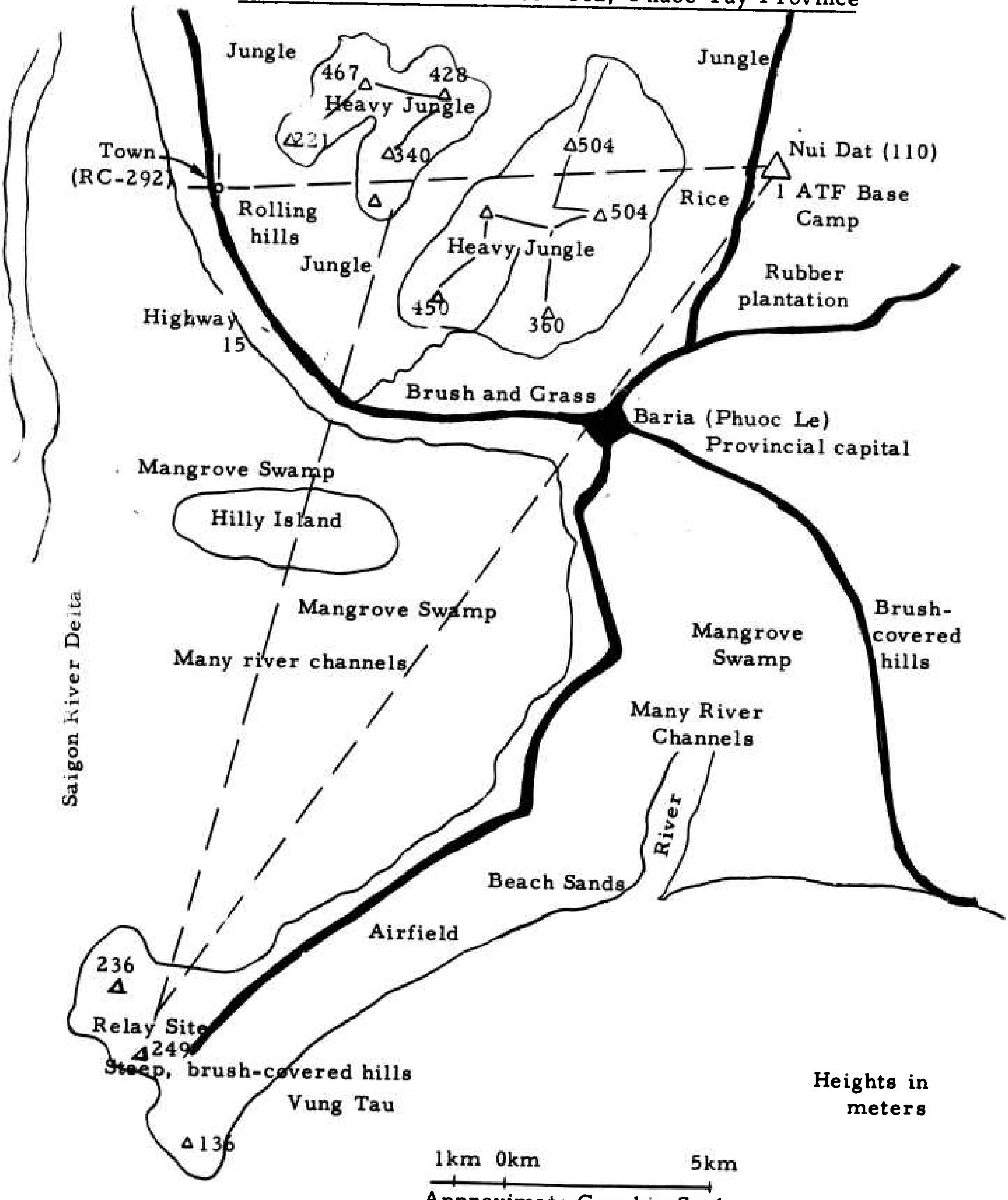
*Presented separately in Appendix B.

FIGURE 26

1st Australian Task Force Area, Phuoc Tuy Province



plantation at Nui Dat. Brigade and battalion radio transmissions eminate from a small peak located in the brigade area. AN/PRC-25 radios with vertical wire dipole antennas of Australian design are mounted in the trees of this hill and the radios are operated by remote control units from brigade headquarters and the various nearby battalions.

One of the areas in which the brigade operated included the coastal road west of the brigade base camp and flanking the mangrove swamps of the Saigon River delta. It can be noted by reference to the sketch map (Figure 26) that this area lies on the west side of the jungled mountain cluster, which rises to 500+ meters above sea level. For this reason, a relay station using AN/PRC-25 radios was established in the hills of Vung Tau with adequate coverage of the coastal operational area. On numerous occasions, however, direct transmissions from Nui Dat to a town at sea level approximately 17 kilometers due west have been carried out over the mountains. These mask the direct line of sight between the terminals by between 300 and 400 meters.

The Vung Tau relay station has supported operations in these mountains, but operations along the coastal road have frequently maintained acceptable communications over the direct, but heavily masked wave path. An RC-292 antenna is usually established on the coastal terminus, but on occasion, units carrying only the "head" of an RC-292 on mobile operations along the coastal road (highway 15) have managed to establish direct non-profiling contact with Nui Dat.

1st BRIGADE, 101st AIRBORNE DIVISION

In the fall of 1966 when this unit was first visited, it occupied an advanced base camp north of Tuy Hoa, Central Vietnam. The brigade area of operations extended inland for approximately 60 kilometers, to the general area provincial border between Phu Bon and Phu Yen provinces. The unit maintained excellent communications with its forward battalions operating in the rugged high ground over ranges which approach 70 kilometers in some examples cited by brigade signal and infantry personnel.

Immediately to the north of the base camp, a relay station using AN/VRC-46 equipment with automatic retransmission capabilities, was emplaced on a rounded granitic rhyolite mountain 391 meters in altitude. From this point, even though many non-line of sight wave paths existed, excellent communications were possible over the entire brigade tactical area of operations.

Communications between the base camp at sea level and a hilltop relay site adjacent to the hamlet of Dong Tre were also carried out at a range of 27 kilometers over hill masks of 200 and even 300 meters, using AN/PRC-25 radios with RC-292 antennas (Figure 27). Vegetation between the two areas is sparse, generally a mixture of secondary jungle and grasslands. Numerous V-shaped stream valleys cut the region, and summits higher than the masking topography flank the wave path.

Despite the well-placed relay station at the base camp, considerable communications in the brigade tactical area of operational responsibility (TAOR) existed on a point to point basis, and the relay facilities are generally considered "back-up." The remarkable performance of the AN/PRC-25 in this region allowed such communications in non-profiling situations. This permitted the more sophisticated relay equipment to be used in circumstances where communications were truly "out" because of unfavorable terrain.

A spectacular example of this was the link operated by the long range reconnaissance patrol of the brigade. They maintained 5 x 5 communications between their base camp in the brigade base area and their advanced relay station, more than 50 kilometers to the northwest (Figure 28). In the operational mode, both terminals were using RC-292 antennas. As a demonstration for the study group, both stations, on signal, switched from their RC-292 antennas and continued their traffic on their long whip antennas. Although the signal dropped in strength and quality, it still provided readable communications over this distance.

The 1st Battalion of the 327th Infantry (Airborne) (1/327) was located in the same area as the long range reconnaissance patrol relay at the time these units were visited. The battalion handled their traffic via the brigade relay station, but they, too, reported direct communications upon occasion. The battalion also maintained communications with their basic companies which were operating in valleys essentially radial to their ridgetop command post.

QUANTIFICATION OF NON-PROFILING COMMUNICATIONS

On the basis of such spectacular samples of non-profiling communications with the AN/PRC-25 man-pack radio, it is hoped that such performance may be quantified by the data collection program among U.S. and allied units. Thus, an appropriate base of examples may be analyzed in the fashion in which range and other physiographic data is being examined from the Vietnamese forces. From this

analysis should come a better understanding of the non-profiling communications phenomenon and other aspects of the physiography as they affect VHF tactical radio performance. Such understanding may eventually lead to an ability to predict communications of this nature, and aid tactical commanders in their communications planning, particularly in the necessity for and siting of relay stations.

FIGURE 27

Radio Wave Path Profile, Tuy Hoa to Dong Tre
1st Brigade, 101st Airborne Division

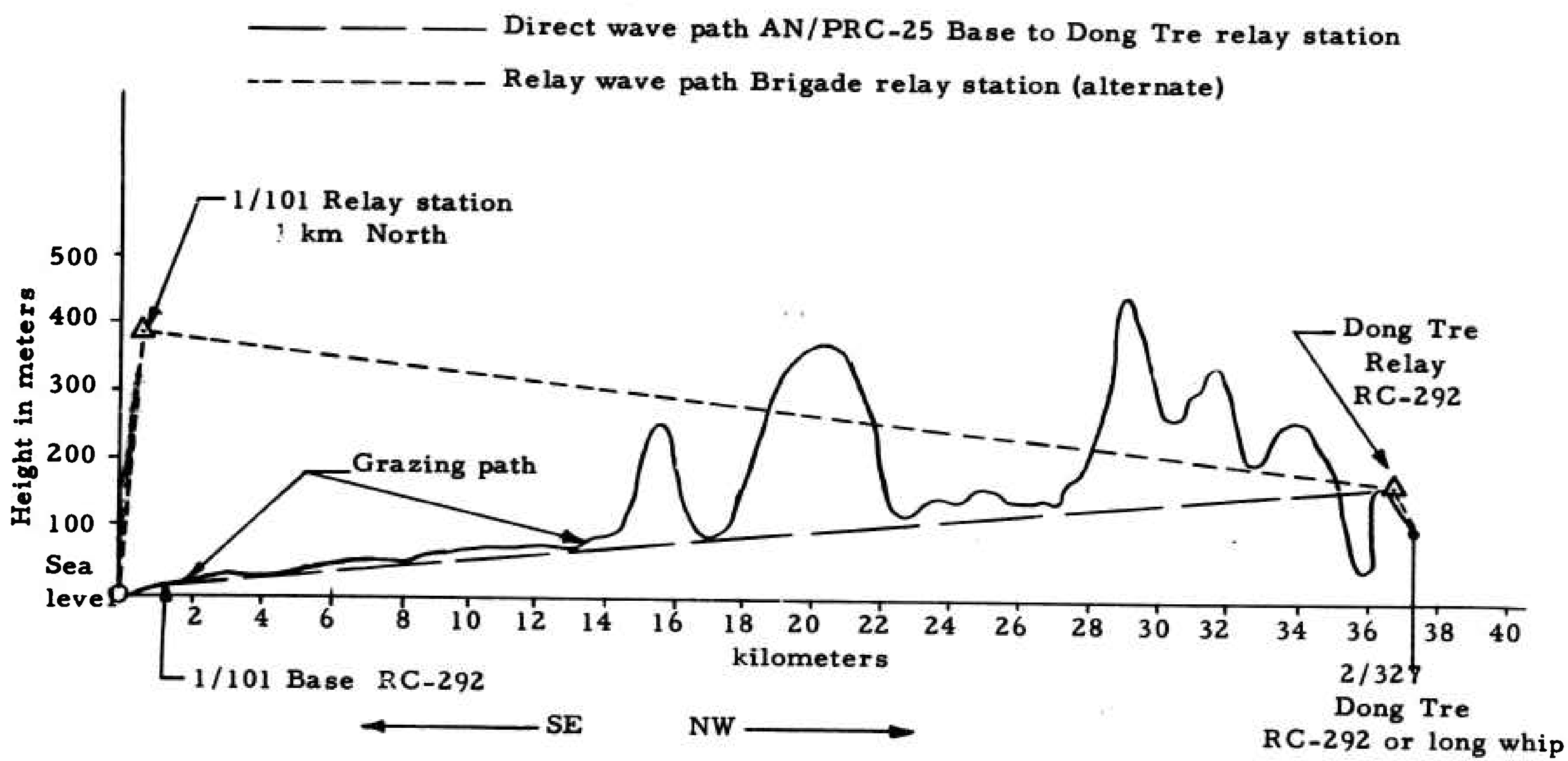
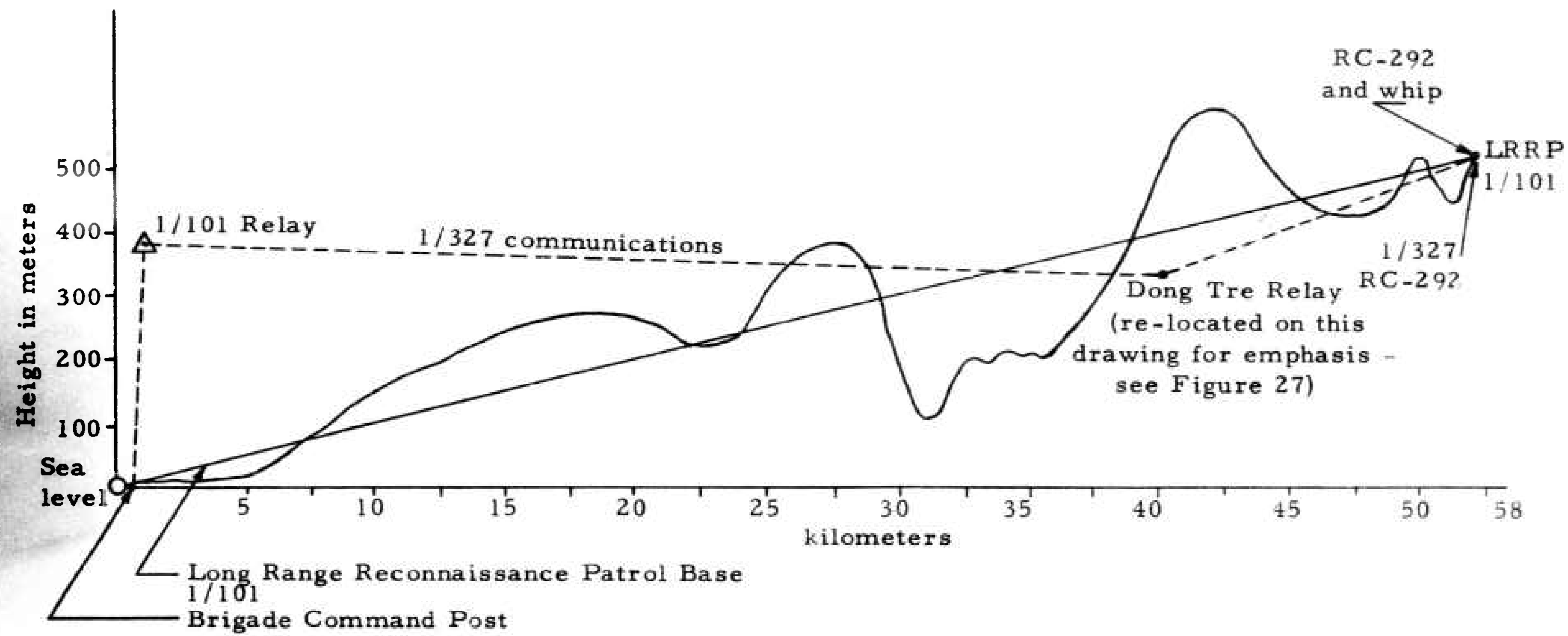


FIGURE 28

Radio Wave Path Profile, Tuy Hoa to Advance Patrol Base
Long Range Reconnaissance Patrol, 1st Brigade 101st Airborne Division



RADIO SPECTRUM OCCUPANCY ANALYSIS

GENERAL

The radio spectrum occupancy task was initiated in March 1966. Field work was completed in July 1966 and a report was issued in September 1966*. This report contains a study of the management of radio frequencies used by small ground units in the Republic of Vietnam. It examines the impact of channel use and management upon tactical military radio communications.

Problems associated with interference by unwanted stations have long been a major drawback of the military use of the AM (HF) band. Such lack of reliability has been a major contributing factor to the use of the FM (VHF) band for short range military communications. Because of the increased commitment of troops to the RVN, indigenous, U.S., and Free World Forces, all heavily equipped with tactical radio equipment, a similar interference situation is developing in the FM (VHF) band.

The approach to the problem was made in three major areas. These were: a study of frequency management at both the governmental and military levels in Vietnam; a program of monitoring and observing the broadcast and lower high frequency bands (500 kHz - 12 MHz); and a study of distribution of types and quantities of radio equipment to the military and paramilitary forces of the Republic of Vietnam. Based on these data, a study was conducted on the use and management of tactical radio frequencies in Vietnam. The conclusions and recommendations are extracted below.

CONCLUSIONS

1. The Postes, Telephones et Telegraphes (PTT), prime management facility for all frequencies in the RVN, is seriously understaffed. It therefore cannot cope adequately with its mission. The strain of military draft requirements; government-imposed salary limitations; and lack of trained Vietnamese communications engineers limit the agency's capabilities in the use of high capacity microwave communications. A lack of skilled management personnel, business machines,

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*The Management and Use of Tactical Radio Frequencies in the Republic of Vietnam, Special Report No. 1: Booz Allen Applied Research Inc., Southeast Asia Operations, September 1966. (Confidential.)

and monitor equipment similarly limits their frequency management capability.

2. There is a heavy dependence on low-speed, omnidirectional HF communication between fixed and semifixed stations. Vietnam never had an adequate land-lines net, and in the current tactical situation, vulnerability of land-lines would make their installation impractical. Thus, heavy HF activity increases the problems of frequency congestion for tactical mobile users for whom the HF band is indispensible when terrain or vegetation prevent practical utilization of VHF.

3. U.S. and FWF units currently operate field tactical radios in the 20-27 MHz and 54.9 - 75.95 MHz, frequencies which are not currently available to the RVNAF. If, as contemplated, radios operating in these frequencies are made available to the RVNAF, frequency coordination problems and interference in these ranges will increase.

4. The continuing use of older equipment which requires 100 kHz channel spacing prevents full advantage being taken of the 50 kHz channel-spacing capabilities of the new series of tactical radios such as the AN/PRC-25. Equipment compatibility requirements typified by communication with the obsolescent AN/ARC-44 in aircraft prevent full exploitation of the 54.9 - 69.9 MHz range.

5. FM (VHF) tactical communication frequencies originally conceived as tools of short range military operations, have assumed some of the characteristics of medium range communications with the increased use by both RVNAF, U.S., and FWF of airborne command posts for the convenience of commanders on reconnaissance or to extend the range of command beyond that obtainable on the ground. Logically, the effective line of sight of VHF radios increases and additional interference problems emerge as the effective radii of transmission and reception are extended.

6. Increasing interference is reported by U.S. and FWF in the FM (VHF) bands. It is greatest on a consistent basis in the rolling hills and rice valleys immediately north of the Mekong and in the northern delta region itself. Much of this interference is from Vietnamese-speaking stations. The assumption is frequently made that these are enemy stations which, from the nature of the FM (VHF) propagation are probably within the tactical area of the unit encountering the interference. Units so harrassed have no capability to determine the source of such interference, particularly as to whether it emanates from friendly Vietnamese sources or is enemy "jamming."

The interference problem is being further complicated by actions taken to extend the range of radio equipment. Some of these are: (a) the extensive use of the elevated antenna RC-292, even by low echelon tactical units; (b) increased use of airborne command posts and airborne relay stations, as cited previously; and (c) the proposed introduction of the AN/PRC-25 amplifier.

Other factors which are contributing to increased interference are the continuing buildup of U.S. tactical forces and the changeover of the RVN RF/PF units from the AM village radio system to the AN/PRC-10 now that ARVN has assumed command of these units. If U.S. tactical forces are committed to the Mekong Delta, frequency management and control problems of RVN in the IV Corps area will increased massively.

7. The cluttered state of the AM (HF) band causes some major non-tactical users with automatic equipment to run their transmitters continuously to keep other stations off their frequency. This waste of a limited natural resource is frequently increased by omnidirectional transmission.

8. Experience in Vietnam clearly shows that the introduction of single sideband AM (HF) equipment is resulting in a significant reduction in interference and thus is arousing new interest and respect for the characteristics of the AM (HF) band. Narrowband reception as well as transmission and highly stable signals are essential requirements for high quality military communications in Vietnam. AM (HF) single sideband has a high record of reliability in this area.

9. Research indicates that there are "patterns of occupancy" of the AM (HF) band and that they are similar throughout most of Vietnam. These data, if made generally available and kept updated, would significantly help the tactical military user as a substitute for the extensive advance monitoring of projected frequencies currently practical only for non-military and special military users. Such data should be considered along with the currently published data on propagation.

10. Assignment of certain "clear" AM (HF) channels to II Corps and III Corps tactical zones in Vietnam with duplicating or shared assignment to I and IV Corps on the basis of greater geographic separation requires close examination. Interference could be lessened by a comprehensive plan of frequency sharing and pooling, considering the physical geography, distances involved, and the characteristics of the HF skywave and groundwave propagation.

11. A basic two-element horizontal antenna is being used successfully for vertical beaming and omnidirectional skywave communications by U.S. Special Forces in Vietnam. Tactical units requiring short distance AM (HF) communications beyond groundwave range should be able to reduce interference at medium and long ranges by using such an antenna.

12. Spurious interference is a common problem when receivers and transmitters are operational in the near field of other mobile radios in tactical headquarters. Operators continue to be taken by surprise by this type of interference, particularly when suddenly developing tactical situations cause unusually intense activity by numbers of mutually supporting command groups located in close proximity for the first time in a concentrated headquarters.

RECOMMENDATIONS

1. The Government of Vietnam and the RVNAF should be encouraged to enhance the capabilities of the PTT by seeing that adequately trained personnel are made available at salaries commensurate with the nature of the responsibilities of the PTT as frequency managing agency for the nation. Sufficient automatic data processing equipment should be provided so that their frequency management task may be automated to the maximum possible extent.

2. Maximum use of 50 kHz channel spacing equipment is encouraged. 100 kHz spaced equipment should be phased out as rapidly as possible to units not requiring extra flexibility or compatibility with the new equipment. This action will greatly increase the amount of channels available in the VHF range when it is fully implemented.

3. MAC-V plans for the management of tactical VHF (FM) frequencies to be decentralized should be supported to the maximum extent possible, and the rigidity of high-echelon control of these frequencies should be relaxed. Thus, greater tactical flexibility for RVNAF, U.S., and FWF may be achieved.

4. Users of airborne command posts and relay stations must consider the effects of greatly increased radii of VHF propagation, and the possible tactical implications on neighboring units within these radii. Aircraft heights, radiated powers and time on the air should all be minimum.

5. The use of directional FM (VHF) antennas at battalion and brigade headquarters should be considered in order to provide limited

communications intelligence in areas where interfering signals are a problem. Evidence of blatant enemy radio activity at short range could thus be indicated.

6. Use of elementary directional antennas by operational base stations is further dictated by requirements to avoid either causing or receiving interference from friendly forces. A survey of the advantages and disadvantages of simple directional antennas to reduce frequency congestion and to increase range and reliability is recommended. Considerations must include feasible lightweight designs usable within the tactical environment of Vietnam, and within the typical operational scenarios encountered by small tactical units in which control of manoeuver elements is exercised from a fixed or semifixed base. Consideration should be given to the development for acceptability testing in Southeast Asia of a lightweight, robust, man-transportable and rotatable directional antenna covering the range 30 - 70 MHz for use with the AN/PRC-10 and AN/PRC-25 radios. The antenna should be no more complex than a vertically-polarized yagi and may be as simple as a cardioid unipole. A provision for a rapid switch to the omnidirectional antenna would also be required.

7. Attention must be given in the design stage of new equipment to front end selectivity. Design must generally reflect the requirements for reduction of mutual interference when receivers and transmitters are operated within the near field of other radios in tactical headquarters.

8. It is strongly recommended that users (tactical and non-tactical, military and non-military) of the HF band, (a) refrain from using automatic equipment to "block" or consolidate their holds on assigned frequencies, or (b) as a minimum step restrict this practice to highly directional long range transmissions.

9. It is recommended that all new tactical radio telephone equipment designed to operate in the AM (HF) band employ the single sideband system or a similar narrowband transmission and reception technique. Receivers without narrowband capability and transmitters without compatible frequency stability and modulation should be phased out as quickly as dictated by cost and availability of new equipment. The old equipment being subject to interference generate unreliable signals and add further to the congestion through protracted tuning calls and repeats.

10. It is recommended that a long-term program of monitoring the AM (HF) band in terms of the patterns of occupancy be set up at four

appropriately located receiving sites in Vietnam with the objective of assembling the data and analyzing occupancy of the AM (HF) band. It is further recommended that data gathered by this effort be continuously made available to military tactical users, particularly those concerned with the local assignment of frequencies. The quality of a prospective frequency in terms of the probability of loss of intelligibility through interference must be considered along with quality in terms of propagation in the relevant conditions of terrain and ionosphere.

11. It is recommended that, in Vietnam, AM (HF) channels be pooled between I Corps and III Corps; between II Corps and IV Corps; and between I and IV Corps, allowing each corps a maximum quota of clear channels. By extending the geographical separation it is improbable that duplicated frequencies would be within groundwave distance interference range of each other, while in some cases the skip wave distances may result in less interference than presently exists.

12. Tactical units employing AM (HF) radios with short distance requirements should endeavor to reduce interference commensurate with their operational requirements by (a) using the lowest frequencies which will provide adequate signals, (b) using vertical antennas for groundwave communications, and (c) beaming vertically from fixed or semifixed base stations for short range omnidirectional skywave communication. The latter technique is currently practiced by some elements of the U.S. Special Forces using a two element horizontal antenna. More general use of antennas of this type is recommended for skywave communications.

SECOND PHASE ACTIVITIES

In implementation of recommendation number 10 above, the Advanced Research Projects Agency requested that an extension of the frequency monitoring task be instituted. This task is being carried on by signal personnel of ARVN under the direction of the Signal Project Officer of the Combat Development Test Center (CDTC). Management assistance is being provided by the Booz Allen study group.

In this follow-on task, the HF band is to be continuously monitored in four widely separated areas (Figure 29). Locations selected were:

I Corps area - Da Nang
II Corps area - Pleiku
III Corps area - Bien Hoa
IV Corps area - Can Tho

FIGURE 29

Original map compiled
by JUSPAO, Saigon, August 1965

R-390/URR radio receivers have been acquired; operator training is well underway; special monitoring forms have been printed and distributed; and the monitoring installation at Bien Hoa has been completed*.

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*As the report goes to press, the monitoring station at Bien Hoa has been operating for approximately one month and is logging 500-600 stations per day. The monitoring station at Pleiku began operation on 30 January and the remaining stations will be installed before the end of February.

DIRECTIONAL ANTENNAS AT TACTICAL LEVELS FOR COMBAT FORCES IN VIETNAM

GENERAL

The conclusions and recommendations of the study of the use of radio channels in Vietnam describe communications problems which arise from the conflicting needs at tactical levels, on the one hand for greater range and depth of command, and on the other, the need for complete assurance of frequencies clear of interference for reliable command and control at all times. This conflict of requirements has always posed a problem with HF communications. It is almost impossible to assure reliability at these frequencies in terms of freedom from interference throughout typical operations. Tactical VHF radio was introduced to improve this situation.

Tactical VHF equipment has in the past provided a fair measure of freedom from interference albeit with limited range. This is no longer true for the Vietnam conflict. Further, in Vietnam the trends in operations are for tactical units to extend the range and speed of their pursuit of the guerrillas. This underscores the problems surrounding the provision of adequate VHF ranges without interference. These trends also draw attention to the basic problem of providing adequate ranges economically in terms of equipment, weight, reliability, and cost.

Increased VHF radio range is usually achieved in the field by stepping up the radiated power with heavier equipment, for example, switching from the AN/PRC-25 to the AN/VRC-46; by switching to a larger antenna, for example, from the tape or the long whip to the RC-292; or by locating at a higher elevation for wider propagation, for example, locating a tactical relay station on a hill feature, in an aircraft or in a helicopter. These techniques usually achieve the range and flexibility currently needed, but they do so at the expense of potential interference radiated over a vast unwanted area with an appalling loss of energy.

Directional antennas would achieve significantly increased ranges without these disadvantages. It is unfortunate that in most tactical situations in Vietnam, command nets have stations spread over wide arcs, which no single directional antenna could cover with worthwhile gain. Thus, in spite of the importance of the requirement to eliminate omnidirectional radiation, there generally appears to be no practical possibility of application of directional techniques to replace omnidirectional operation except in certain circumstances.

The purpose of this report is to discuss these circumstances so that their importance may be weighed against the size, weight, complexity, and cost of a feasible directional VHF antenna.

Interest in beamed radio techniques has been encouraged by the arrival of large quantities of the reliable, easy to operate, man-pack AN/PRC-25 and the AN/VRC family of tactical VHF radios. Commanders desire to extend their control with these radios to command over more extensive radii than those provided by the basic sets. The interest in beamed radio is supported by frequency coordinators who are faced with a mounting problem of finding clear channels. For example, Headquarters I Field Force-Vietnam (FF-V), with responsibilities similar to a U.S. corps headquarters, in November 1966, had valid requests for more than 400 VHF nets with resources limited to 70-80 channels. Channels are so scarce that they are sometimes pirated by both U.S. and allied units and interference is reported on a high percentage of U.S. command nets.

The frequent appearance of Vietnamese voices on channels allocated to allied forces indicated difficulties in achieving completely effective coordination with local ARVN and paramilitary forces. The expected introduction to ARVN of the AN/PRC-25 to replace the shorter range AN/PRC-9/10 (restricted to the band 27.0 - 54.9 MHz) will undoubtedly increase the complexities of this aspect of coordination.

Interference, when it occurs, is as upsetting to the Vietnamese as it is to the allies. The language barrier delays clarification and meanwhile, non-professional jamming sometimes develops as a technique to gain control of the channel. This is not surprising in view of the fact that many commercial and military stations with properly authorized channels feel bound to hold these channels not by reference to authority so much as by continuous transmission of code signs and other non-essential signals on full power when traffic is non-existent.

TACTICAL SITUATIONS SUITABLE FOR DIRECTIONAL VHF COMMUNICATIONS

GENERAL

Tactical radio equipment for use forward of brigade headquarters is generally restricted to the very inefficient omnidirectional mode because effective lightweight directional antennas which might be acceptable at these levels have not been developed. The nature of

deployment in operations from brigade forward have not previously generated a need for directional techniques which was strong enough to offset the disadvantages. Hence the lack of suitable equipment. However, early in 1966 in the course of this study, there were indications that it would have been feasible in many situations for these units to employ directional antennas thus reducing the wastage of radiated power and the unnecessary interference resulting from omnidirectional transmission and reception. Some of these situations are examined here.

APPLICATION TO U.S. SPECIAL FORCES

Discussions of Special Forces patrol tactics as they affect communications have been held at Headquarters 5th Special Forces Group, and at various A, B and C detachments. From some points of view, Special Forces have the most difficult to manage command and control system in South Vietnam. Their communications requirements include a variety of ranges to different types of patrols and bases each with a special set of problems to be overcome.

The orthodox chain of command is from Headquarters 5th Special Forces Group, Nha Trang, to C detachments which are associated with the ARVN Corps Headquarters. The C detachments command formally through B detachments which are found in association with an ARVN division and are located in provincial capitals. The B detachments are responsible for the A detachments throughout South Vietnam. The A detachments work in cooperation with indigenous troops who have their own communications from the A detachments, both forward to patrols and to the rear, generally to the nearest district headquarters. The A detachments are the most forward element of the Special Forces. They are the spearhead of the operations.

Special Forces Patrols

Patrols work very actively from these A detachments, but because they are limited in numbers their patrols are not nearly as numerous as are those from a typical U.S. infantry or marine battalion. Frequently, the A detachment is concerned with a single patrol. In these circumstances they do not have the problem of simultaneous communication with a number of units spread over a wide arc and a directional antenna with good gain would be a useful tool at the base camp to boost VHF signals on both transmit and receive.

The term "useful tool" can be very much of an understatement. For example, a patrol from an A detachment (III Corps area) was

ambushed in a locality in which VHF communications were marginal. A member of the team was seriously wounded and a helicopter evacuation was urgently needed. The patrol had to move cautiously and took one hour to reach a location from which communications could be re-established. The man died and in the opinion of the team, might have lived had he not been moved and had he been evacuated promptly. A good directional antenna at base could have provided the boost needed for coverage of this marginal area where signals were audible but unreadable.

The question may well be asked, "Why use VHF sets under these marginal conditions?" The communications equipment preferred by the U.S. element of short range patrols operating in areas more or less local to A detachments is usually the AN/PRC-25. This is because of the lightweight, reliability, and simplicity of the AN/PRC-25 compared with HF. Further, HF suffers from an inherent lesser reliability inside the range of VHF because of the possibility of interference from outside the local command area.

Special Forces units require maximum flexibility in their patrol activity. They are frequently in operation beyond the range of the AN/PRC-25 because of screening by vegetation or terrain. Many so-called dead spots or marginal areas may be encountered. Patrols move through them as quickly as possible or avoid them. In these cases there is a requirement for additional power and sensitivity of the order of magnitude which could frequently be provided by conventional VHF directional antennas.

Special Forces detachments do not have the resources to set up relay stations and defend them without considerable sacrifice of men and equipment urgently needed elsewhere. They use the ground relay technique but as already indicated the nature of their operations, the terrain and the strength of the enemy often pose major problems which make alternative solutions attractive.

Special Forces A detachments place emphasis on their HF (CW) capability for tactical command and control in situations where range or other considerations dictate this mode. The fact remains, however, that good voice communications provide faster exchange of essential information between commanders in small unit tactical situations. Thus, the conclusion is reached that a lightweight, simple and low cost directional antenna would be a worthwhile asset to A detachments enabling them to cover marginal areas and to increase the TAOR within which reliable voice communication is obtained.

Special Forces Voice Links to B Detachments

It is advantageous for operational command purposes to locate Special Forces A detachments so that they are within VHF range of the controlling B detachment. Elevated RC-292 ground-plane antennas are used in these circumstances. The VHF voice mode is preferred for speed and reliability to shorten the reaction times of fire support and reinforcements. This VHF net is, of course, supplemental to the HF (single sideband and continuous wave) nets normal to Special Forces. HF (CW) is almost always used for written messages at this level.

Directional antennas, if available at A detachments, would permit more flexibility in planning camp locations. They would also contribute to the reduction of area interference. However, it is apparent that the directional type of antenna in this role may introduce a disadvantage if complete attenuation of other "out stations" such as A detachments in the B detachment net results. Two stations may attempt to call the B detachment simultaneously and obviously one must be asked to stand by. However, this problem also occurs when using omnidirectional antennas. The greater power and sensitivity of the directional antenna should override this disadvantage.

A similar delay problem is common to nets using the manual relay technique to repeat messages sent between stations which are out of contact. Experience of delays from this cause among busy groups in III MAF where the technique is used extensively, are said to be minor and comparatively infrequent. Short calls are customary and experienced estimates of the delay time show that it is generally less than 10 seconds total.

Summary - Special Forces Applications

To sum up the Special Forces requirements, it appears that the need for tactical VHF directional antennas is limited but in some cases important. The acceptibility of such antennas would depend on signal gain, reliability, complexity, and cost, rather than the limitation of effectiveness, to say, 40-50 degrees of arc for any single communication. Rotation of the antenna to a new direction is of course assumed to be possible by a quick and simple maneuver. It should be noted also that simple camouflage techniques are available so that there is no need for the antenna to "point" arrow-like to the other station. The need for security is often paramount with Special Forces and this factor is considered along with general design feasibility later in this paper.

RECONNAISSANCE PATROLS

A significant percentage of U.S. and FWF units in Vietnam now field specialized reconnaissance patrols (see Appendix B). Their mission is to gain target intelligence and general information about the enemy frequently in the communicating fringe area beyond the tactical area of operational responsibility of the "orthodox" combat units.

Good fast communications are vital to the success of these units. The importance of the radio link is demonstrated by the fact that it is usual for aircraft to be used to re-establish communication with reconnaissance patrols if contact is lost without explanation for more than an hour or so. When communications fail unexpectedly through screening by vegetation or terrain, these patrols typically move to better radio locations as quickly as possible to re-establish contact. As is the case with the Special Forces A detachments, it is apparent that marginal areas and "dead" zones create difficulties and tend to dictate tactics. These areas must be avoided or covered by the expensive and sometimes dangerous technique of setting up relay stations. Another alternative is to carry an HF radio with attendant problems as discussed earlier.

The reconnaissance units have another factor in common with Special Forces A detachments. Patrolling is a primary mission and they therefore tend to manage their patrols on an individual basis. Reconnaissance units questioned expressed interest in directional antennas and indicated that they would use them at base locations in situations where a patrol was experiencing communications difficulty. Another radio at base was considered to be justified for use in the directional mode in these circumstances.

BATTALION AND COMPANY RELAY STATIONS

The surprising success of tactical relay stations in Vietnam is evident from this study. The effectiveness of these stations and the failure of the enemy to react with countermeasures is an important factor in the development of larger TAORs. Increasing use is being made of automatic rebroadcasting at these relay sites. At the tactical relay there is frequently what amounts to a one-to-one link from the relay station to the battalion CP and sometimes from the relay station to a single small unit which has created the requirement for the relay. Received interference is most frequent at relay stations and can be troublesome with automatic rebroadcasting which will retransmit unwanted signals.

These are circumstances for the use of directional antennas to increase communications security, decrease interference, and increase the range at which the unit can operate.

BATTALION TO BRIGADE COMMUNICATIONS

Emphasis has been given to communications forward of battalion. There is, however, a role for directional systems above this level on VHF nets linking battalion and brigade or battalion to division. At this level a demand for increased traffic capability is evident. Multiplex converters (four channel) are being tested for the AN/VRC-46 and also for the AN/PRC-25 with favorable reaction. Auxiliary power supplies are required for the AN/PRC-25 in this mode. These radios are not limited to line of sight and provide a flexibility in terms of ability to overcome terrain masks that is a major factor in successful command. (See Wave Path Physiography Analysis.)

Multiplex operations of these VHF sets can be expected to require higher signal levels for ranges equal to those obtainable with single audio channel transmission. Directional antennas would provide this gain as well as reduce the interference.

This paper deals with the possible implementation of VHF directional techniques through the introduction of directional antennas for existing equipment. It is interesting and relevant, however, to point up the use in Vietnam of the sharply directional higher frequency AN/TRC-27 multichannel equipment which is used by the III MAF through regiment down to battalion level when the logistic situation and terrain permit. As would be expected, this set is heavier and more complex than the VHF (FM) family. The AN/TRC-27 itself works well and the concept of directional radio at this level is accepted but the 400 cycle generators have a very short life between major overhauls. It is unfortunate that the set is not designed for 50-60 cycle power which is readily available.

The short life of the AN/TRC-27, 400 cycle generators, has caused III MAF to use this set in a back-up role to other communications. These other communications in III MAF include wire between base camps. This is surprising because of the distance. However, in III MAF, as in the Army units at this level, the VHF (FM) family of radios remain the tactical mainstay of command and control.

Before describing feasible tactical directional antennas, it is appropriate to note that interest in directional antennas at the brigade-battalion level has resulted in implementation of the beam technique with success among units under command of the 4th Infantry

Division. Antennas have been improvised from radio equipment available to the division. AN/TRC-24 yagi antennas are being used in conjunction with AN/VRC-46's and the AN/PRC-25 sets. Other units at this level, although equally interested, have been less successful in acquiring suitable equipment with which to improvise.

TWO FEASIBLE DIRECTIONAL ANTENNAS

GENERAL

It is apparent from the preceding discussion that there is a limited but important need for directional antennas in the circumstances examined. The conclusion is reached that the provision of this type of antenna would probably be on a very limited basis. Even this limited provision must be dependent on light weight, low bulk, ruggedness, simplicity, low cost and ease of fabrication. Two distinctly different types of directional antennas which have these characteristics contend for consideration for use in Vietnam. These are:

1. An omnidirectional vertical coaxial sleeve antenna convertible to a three element yagi directional array; and

2. A cardioid ground-plane antenna.

AN OMNIDIRECTIONAL VERTICAL COAXIAL ANTENNA CONVERTIBLE TO A THREE ELEMENT YAGI DIRECTIONAL ARRAY

The importance of light weight and other desirable characteristics including low cost, have been emphasized throughout this paper. There are undoubtedly a number of antenna configurations that have these characteristics in some measure. The vertical coaxial antenna is selected for presentation here because it is omnidirectional in its basic form and is very simply adapted to become a rotatable three element yagi array with a gain of up to 7 dB. The description of the basic coaxial antenna which follows is adapted from the American Radio Relay League (ARRL) Antenna Book*.

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The Vertical Coaxial Antenna

End-fed vertical radiators such as the "J" are relatively ineffective because of the tendency of the transmission

*Antenna Book, Tenth Edition, The American Radio Relay League, Inc: Newington, Connecticut, 1964.

line to radiate. This condition becomes worse as the frequency increases, becoming quite bad in the VHF range. Radiation from the line combines with that from the antenna itself to raise the radiation angle. To reduce this difficulty the coaxial antenna was developed. It is used in applications where a non-directional vertical radiator is required.

The center conductor of a 70-ohm concentric transmission line is in effect extended one-quarter wave beyond the end of the line, to act as the upper half of a half-wave antenna. The lower half is provided by the quarter-wave sleeve, the upper end of which is connected to the outer conductor of the concentric line. The sleeve acts as a shield about the transmission line and very little current is induced on the outside of the line by the antenna field. The line is non-resonant, since the characteristic impedance is the same as the center impedance of the half-wave antenna.

Each section of the antenna should be an electrical quarter wave long. The upper section and the lower section, or sleeve, can be 3/4 or 1-inch aluminum tubing. The insulator can be a few inches of polystyrene rod filed down to make a tight fit inside both sections.

A coaxial antenna can be supported from a wooden pole by mounting the sleeve on insulators fastened to the pole, the coaxial transmission line being allowed to drop straight down for at least a half wavelength after leaving the bottom of the sleeve. Alternatively, it can be mounted on top of a pipe mast provided the mast is insulated from the sleeve.

When a coaxial antenna is mounted at the top of a metal mast standing waves may develop on the mast (or on the coaxial cable used to feed the antenna, if the support is non-metallic) even though the sleeve effects a considerable reduction in the coupling between the antenna and mast. When this occurs, radiation from the mast combines with that from the antenna to raise the angle of radiation, thereby reducing the effectiveness of the system.

. . . .

The ground-plane type of antenna has largely superseded the coaxial because the horizontal ground plane is an effective shield between the antenna and mast. On the other hand, it should be noted

that the basic omnidirectional coaxial antenna has one possible physical advantage over the ground-plane antenna. The absence of the ground-plane makes the coaxial easier to erect in brush and forest undergrowth. This is important to patrols which frequently carry the "head" of the RC-292 ground-plane antenna for use in jungle vegetation (see Appendix B). Built as a special patrol antenna the coaxial dipole can be adapted from standard flexible coaxial cable, coiled for porterage and hung from a tree or pole when required*. A great attraction of the antenna in this role derives from its transmission line which drops conveniently from the lower end directly down to the radio. At the same time because of the standing waves induced, this feature creates problems with the basic antenna as pointed out above. Fortunately these standing wave effects can be greatly reduced and to some considerable extent can be used to advantage as described below.

It is apparent that the results of field trials examining the comparative performance of the coaxial and ground-plane antennas in the field environment must be reviewed in order to weigh the relative losses against the advantages which might accrue to the coaxial converted to a tactical directional antenna.

In the event that the losses are in fact unacceptable, they can be effectively reduced by attaching a quarter-wave metal sleeve to surround the coaxial transmission line (and mast if metal) spaced a quarter-wave down the line and mast from the lower section of the driven element of the antenna. The sleeve is connected only to the outer conductor of the coaxial transmission line and only at its upper end. When mast height permits, shielding of the transmission line can be increased by fitting a ground-plane a quarter-wavelength below the lower sleeve.

When these additional coaxial and ground-plane features are considered, it should be kept in mind that tactical units in Vietnam do not normally change VHF channels frequently. Coordination complexities make this procedure difficult. Thus, it may prove worthwhile to fit the second sleeve and/or ground-plane in many tactical situations. Easy and accurate assembly is possible because sleeve lengths and mast positions as well as ground-plane lengths (telescoping sections) would be obtained from reference tables.

A similar (two additional sleeves plus ground-plane) omnidirectional vertically stacked coaxial antenna was designed for civil

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*This configuration has been proposed by Major Herbert M. Rosenthal, USAF, Senior Investigator, Research, Development and Analysis, Research and Development Field Unit-Vietnam.

defense communications*. Modular or building block techniques may be used so that, depending on motivation and tactical circumstances, the basic antenna can be built upon by steps. As is shown below, this building block technique can be continued with surprisingly little additional weight or complexity to form a three element directional array.

The Vertical Coaxial Antenna Converted to a Three Element Yagi

Radiation resistance as measured at the center of the driven element of a three element array can vary over a fairly wide range since it is a function of the spacing and tuning of the parasitic elements. Values can range from the order of 10 ohms to more than 50 ohms**. This variable poses a serious design problem in the conversion of the coaxial antenna to a three element yagi but it does not appear to be insurmountable. Low values of radiation resistance are to be avoided because of the narrower bandwidths associated with them. It seems probable that a 50 ohm coaxial cable can be used in both modes through appropriate selection of element lengths and spacing.

The introduction of the parasitic elements also affects the reactance of the driven coaxial element. However, with the parasitic elements properly tuned, the resonant length of the driven element is not significantly different** whether the antenna is being used in the omnidirectional or unidirectional mode.

The coaxial antenna is limited in bandwidth as is the ground-plane antenna. Converting the coaxial antenna to a yagi further reduces the bandwidth by a very considerable factor. Nevertheless, for a three element beam this bandwidth will be more than ample for the channel width of 50 kilohertz allocated in the VHF (FM) band. However, it will probably be necessary to readjust the antenna for most changes of channel in order to optimize performance. Antenna adjustments can be simple and do not pose a design problem.

The Horizontal Boom Converter

Conversion of the vertical coaxial omnidirectional antenna can be achieved by a very simple mechanical arrangement. A horizontal non-conducting boom is attached at about its center to the top of the antenna element. The upper section of the antenna element must be appropriately robust to support the lightweight boom. The boom sits

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*QST, November 1951.

**ARRL, op. cit.

loosely bolted to the cup so that it can move up and down about its point of attachment to the cup. Figure 30 is an outline sketch of the antenna.

The director and reflector elements are made of light, flexible wires dropped from pulleys at appropriately marked positions along the boom. The wires are marked to match channels and unreeled as required. They are extended to the ground by nylon cords so that the boom can be pulled to a horizontal position after the mast is erected then using the cords again the boom can be rotated about the antenna to the desired direction. After this adjustment the cords are fastened to the ground and reinforce the guying of the antenna system. Using the pulleys and an endless loop arrangement, the director and reflector can be lowered in a minute or two to make the antennas omnidirectional. The increase in weight contributed by the directional conversion is thus kept to the weight of the plastic boom, cup, wire and cord. Without the heavy mast the complete lightweight system could be hung by cord from a tree--foliage density permitting.

Close attention must be paid to the design for tuning the driven element. Tuning is achieved by adjustment of the lengths of the upper and lower sections. A design is envisaged whereby the driven element which, of course, does not rotate, is mechanically but not electrically an extension of the mast. The mast or its top section is made of suitable plastic. The basic driven element is cut for 75 MHz. The additional driven elements are made up of a number of sections which clamp or screw together and are appropriately marked by channels. Two of these sections, one for each end of the driven element, are adjustable verniers marked by channels for precise adjustment of lengths to match channels by means of sliding tubes.

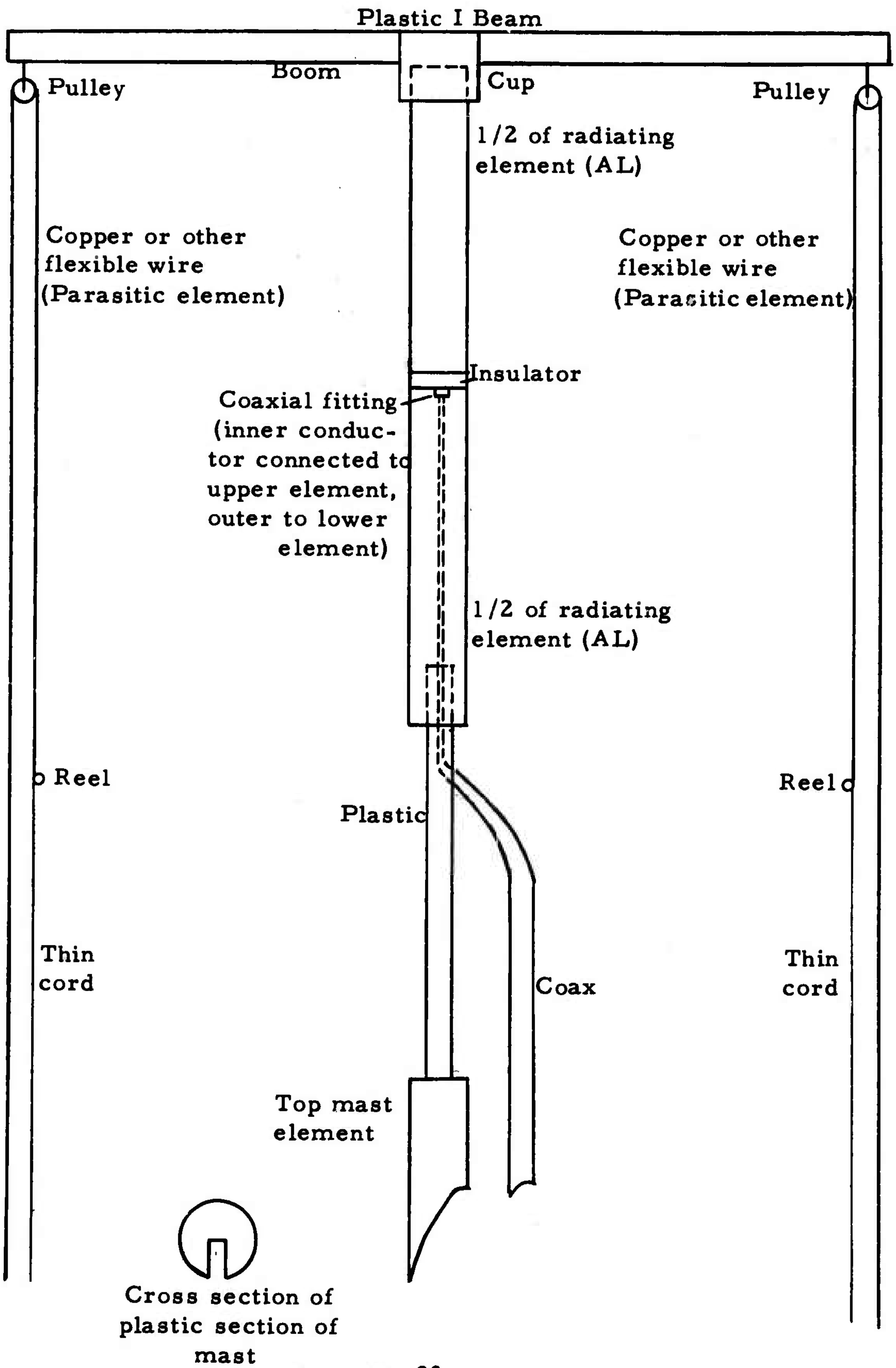
Parasitic reflector and director wire elements drop from points on the boom which are identified by numbers allocated to hook holes along the boom according to the channel group selected.

Coverage of the Coaxial Three Element Antenna

The coaxial convertible three element antenna probably covers an arc in the horizontal plane of the order of 40-50 degrees to the half power points with a maximum forward gain of the order of 7 dB referred to a vertical dipole. The variable effect of the standing waves on the transmission line or mast have not been considered in this estimate. Variables of this type are best determined by experiment in the appropriate environment.

FIGURE 30

The Vertical Coaxial Antenna Converted to a Three Element Yagi - Outline Diagram



Seven decibels is a very significant gain if it can be obtained at the cost of a few feet of plastic I beam and flexible wire. The assumption is made here, of course, that the performance of the coaxial antenna in the omnidirectional mode in the field environment is not significantly lower than that of the RC-292. The additional feature of the three element coaxial is that it should be acceptable to small units where they now use the head of the RC-292. This is a major advantage. In some situations directional antennas are feasible at both ends of links with small units to provide gains up to 14 dB compared with a dipole. This order of power gain obtained on both transmit and receive is equivalent to switching from the lightweight, manpack AN/PRC-25 to heavy equipment of the vehicle or ground radio family, along with their associated power supply problems.

Some interference problems can be expected from the coverage of the directional antenna, but these will be more than offset by reduced radiation in unwanted directions, the measure of control and the directional selectivity of the station in the receive mode. The problems of frequency coordination which are being compounded by increasing range when the increase is omnidirectional have been discussed previously.

An expected limitation of moderately high gain directional systems for use at tactical levels would be their inability to fully match all aspects of operational tactics in some situations. To be acceptable the cost and logistical load must be low and the advantages must be very apparent to the user. Above all, the antenna must be mechanically and electrically reliable, easy to install and easy to dismantle.

Camouflage for the Three Element Yagi Coaxial Tactical Antenna

In some circumstances, particularly those pertaining to certain patrols and small operations, it would be advantageous to use the three element yagi coaxial tactical antenna at base, but security requirements may pose more than the usual problems. The base station directional antenna may be in clear view of the enemy who can determine the direction it is pointing by observing the boom angle, the parasitic element lengths, and spacing.

These calculations on the part of the enemy would enable him to determine which of the two possible pointing directions of the boom was the one in which the operation was occurring.

In these special situations, which will occur from time to time at base camps, it would be worthwhile to adopt simple camouflage

or deception procedures. First, the lower bobbins, insulators or reels should be removed from the parasitic elements. The nylon cord extension and the wires forming these parasitic elements should be of similar thickness and color. Thus the point of transition from wire to nylon insulator should be impossible to determine even when very close to the antenna system.

Additional nylon cords appropriately spaced for confusion purposes could also be dropped from the hook holes on the boom to prevent identification of the elements by measurement of their distance from the driven element.

With this camouflage the enemy must determine which of two 40-50 degree arcs is that in which the operation is occurring.

When these precautions are inadequate, a dummy, lightweight boom can be bolted to the rotating cup at right angles to the real boom. Nylon cords dropped from each side section of the dummy boom would simulate a genuine radiating system impossible to detect as spurious even at the antenna base. This extreme measure would require the enemy to decide which of four possible 40-50 degree arcs was the one in which the tactical operation was occurring.

It is worth noting that the dummy boom and its drop lines can be put to real use by additional engineering which could convert the system to a five element yagi with additional gain and directivity. However, this involved procedure is of academic interest only and cannot be recommended for general use because of the primary need for simplicity in an acceptable field system.

A CARDIOID GROUND-PLANE ANTENNA

The disadvantage of the very limited horizontal angle over which worthwhile gain is achieved with sharply directive antennas is avoided by antennas with cardioid patterns. A commercial cardioid unipole antenna is shown in Figure 31. This figure includes an illustration of a basic omnidirectional unipole and the radiation pattern for both the omnidirectional and cardioid antenna systems. In this general discussion it is unnecessary to go into details of design feasibility for this antenna because systems of this type have been developed and are commercially available. The omnidirectional unipole ground-plane antenna is very similar to the RC-292.

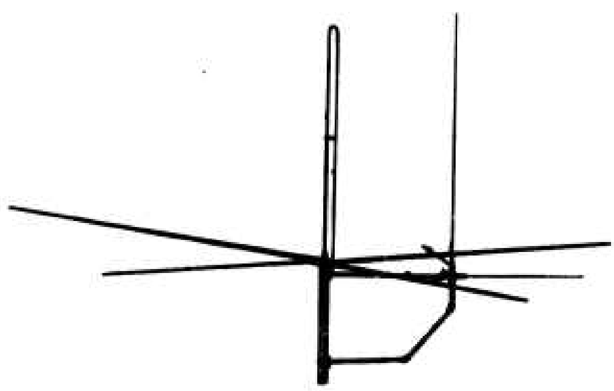
Antennas of the cardioid type produce very wide arcs of forward gain but as would be expected, the gain is considerably lower than for conventional directional arrays. An important feature of

FIGURE 31

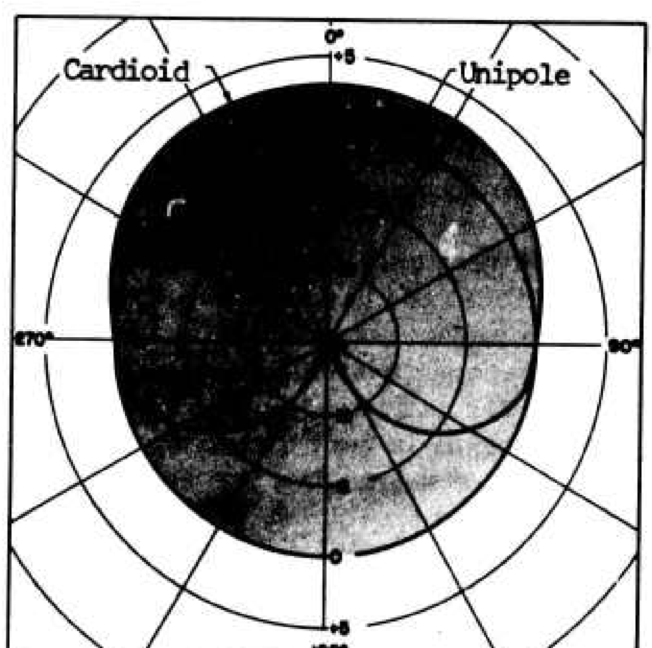
Omnidirectional and Cardioid Unipole Antennas - Outline Diagrams and Radiation Patterns

Omnidirectional Unipole

Cardioid Unipole



Horizontal Radiation Patterns



the cardioid antenna is the very deep null approximately 180 degrees from the direction of highest gain. The wide forward arc of low gain, the comparatively rapid fall-off of coverage "to the rear" and the deep null directly to the rear are most useful characteristics when reduction of interference is required and range beyond the normal is not necessary or is undesirable.

An interference problem which is in this category and could be alleviated by cardioid antennas is encountered at tactical headquarters as well as at crowded relay sites. Relay sites are typically on dominating hill peaks; they are often quite small in area and are sometimes occupied by many tactical relay units. The well-known "Rock Pile" just south of the demilitarized zone is an example. Headquarters by conservative observation may have more than 20 VHF (FM) transceivers crowded in a small CP area. In these situations spurious radiation from transmitters and front end leakage or repeat spots in receivers cause problems. (See section of this report entitled, "Observations on Vietnamese Communications Practices and Problems.)

Optimum orientation of cardioid antennas organized on a group basis for minimum mutual interference could be a significant mitigating factor in these cramped headquarters and relay site environments.

Apart from this special "local" interference it has been pointed out throughout this report that general interference on the VHF (FM) band is now a common occurrence at all levels. A cardioid antenna pattern would be advantageous compared with an omnidirectional antenna in most of these circumstances. However, the conclusion is reached that the three element yagi already described offers much more than the cardioid for tactical units.

APPENDIX A

CODING SHEETS USED IN DATA REDUCTION AND MACHINE ANALYSIS

BASIC DATA COLLECTION CODING
PATROL CARD "A"

Item	Punch Card Columns	Coding Instructions and Remarks
Line item designation	1	Y-Patrol.
Divisional designation	2-3	Enter numerical value only as following examples: 22(Div) 18(Div) 07(Div) If unit is non-divisional, enter only 00.
Line item serial	4-7	Number 001-9999 in sequence as coded by separate "Y" series.
Unit size	8-9	01-Squad 02-Section 03-Platoon 04-Company 05-Reinforced Company 06-Battalion 07-Battalion Combat Team (BCT) 08-Regiment 09-Regiment Combat Team (RCT) 10-Task Unit 11-Brigade 12-(et seq) Add codes to designate new units as needed.
Unit numerical or alphanumeric identifier	10-12	Actual unit designation, using alphanumeric or numeric entry. Use zeros for less than three column entry. Examples: 024-24th Regiment 007-7th Armored Cavalry 477-4th Platoon 77th Rangers A23-Company A 23rd Battalion
Unit type	13-14	01-Infantry 02-Armor 03-Artillery

Item	Columns	Coding Instructions and Remarks
Unit type (cont'd.)		04-Mortar or heavy weapons 05-LLDB (translated as Vietnamese Special Forces) 06-Civilian Irregular Defense Group (CIDG) 07-River Assault Group (RAG) 08-Junk Force Element 09-Naval Patrol Craft 10-(et seq) Add codes to designate new types of units as needed.
Unit affiliation	15-16	01-ARVN 02-RF 03-PF 04-Ranger 05-Airborne 06-Marine 07-Paramilitary (hamlet militia, police, or other paramilitary force) 08-U.S. advisory element with Vietnamese forces 09-U.S. combat force 10-(et seq) Add codes to designate additional types of units as needed.
Date-Time group Day - cols 17-18 Month - cols 19-20 Year - (last digit) col 21 Time - cols 22-25	17-25	Enter day, month, year and hour as following example: "21 November 1965 0845" Day - cols 17-18 "21" Month - cols 19-20: "11" Year - col 21: "6" Time - cols 22-25: "0845"
Unit mission	26-27	01-Reconnaissance 02-Security 03-Ambush 04-Escort 05-Search 06-Extended or long range 07-Perimeter security
Composition of patrol or unit: Cols 28-30: No. of men Cols 31-32: No. of vehicles Cols 33-34: Types of vehicle as indicated	28-34	Code columns 33-34 as: 01-Jeep 02-Truck 03-Armored car (wheeled) 04-Armored Personnel Carrier 05-Tank 06-(et seq) Add other codes as needed.

Item	Punch Card Columns	Coding Instructions and Remarks
Unit assignment	35	1-Assignment to units listed in cols 2-14. 2-Attached to unit not own, designated in columns 11-13 on Patrol Card "B". 3-Operating independently.
Radio type	36-38	001-019: AN/PRC-type radios: 001-AN/PRC-10 002-AN/PRC-6 003-AN/PRC-25 021-029: HF man-pack tactical radios: 021-AN/GRC-9 022-AN/GRC-87 031-049: Vehicular VHF or HF tactical radios. 051-059: Aircraft-mounted air-ground tactical radios. 061-079: Naval tactical radios. Does not include "Army man-pack" radios used aboard naval craft. 081-099: Available for coding additional field tactical radios. 101: USOM rural security and police radios: 101-HT-1 102-TR-20 103-TR-5
AM/FM	39	1-AM 2-FM
Frequency in MHz or kHz	40-44	Numerical entry from right. Decimal point between columns 43-44 for MHz only. Enter kHz directly from right.
Modulation	45	1-Voice 2-Continuous wave 3-Single sideband

Item	Punch Card Columns	Coding Instructions and Remarks
Antenna type	46	1-Short whip or tape 2-Long whip 3-Wire 4-RC-292 5-(et seq) Code additional types as required.
Distortion	47	0-None 1-Static 2-Other station interference 3-Channel busy
Success of radio contact	48	1-Yes 2-No
Origin of communication	49	X-Base Y-Patrol Z-Another patrol W-Support arms or air T-Airborne relay U-Fixed relay V-Shipboard relay
Unit contacted	50	Same coding as column 49 above.
Duration of patrol	51-53	Numerical entry. Decimal point between columns 52-53. Enter minutes to decimal fraction of hours.
Contact with enemy	54	1-Yes 2-No
Base station coordinates	55-62	Alphanumeric direct entry of UTM coordinates. (This entry may not be present in patrol report - place names may be used, if so enter "p").
Patrol coordinates	63-70	Alphanumeric direct entry of UTM coordinates. (This entry may not be present in patrol report - place names may be used, if so enter "p").

Item	Punch Card Columns	Coding Instructions and Remarks
Weather at current patrol location	71	1-Clear 2-Cloudy 3-Rain
Topography at current patrol location	72	1-Flat 2-Valley 3-Hillside 4-Hilltop
Vegetation at current patrol location	73	1-Open 2-Brush 3-Trees
Corresponding line item	74	Is there a corresponding base station line item? 1-Yes 2-No
Data sheet number: Sheet No. Cols 75-78 Line No. Cols 79-80	75-80	Enter sheet and line number from original field data sheets.

PATROL CARD "B"

Line item designation	1	Y-Patrol
Card designation	2	Enter "B" in all cases
Line item serial	4	Number 0001-9999 in sequence as coded in separate "Y" series.
Transmission time	8-10	Minutes/seconds numerical code. Seconds to decimal fraction of minutes. Example: 14.5 minutes.
Assigned unit	11-13	Entry in this column only if there is a "2" in column 35, Patrol Card "A". Unit code as columns 10-12 on Patrol Card "A".
Data sheet number: Sheet No. Cols 75-78 Line No. Cols 79-80	75-80	Enter sheet and line number from original field data sheets.

Blank columns on patrol card "B" are 14-74.

BASIC DATA COLLECTION CODING
BASE STATION CARD

Item	Punch Card Columns	Coding Instructions and Remarks
Line item designation	1	X-Base station (fixed) Z-Base station (mobile)
Division designation	2-3	Enter numerical value only as following examples: 22(Div) 18(Div) 07(Div) If unit is non-divisional, enter only 00.
Line item serial	4-7	Number 0001-9999 in sequence as coded by separate "X" and "Y" series.
Unit size	8-9	01-Squad 02-Section 03-Platoon 04-Company 05-Reinforced Company 06-Battalion 07-BCT 08-Regiment 09-RCT 10-Task Unit 11-Brigade 12-(et seq) Add codes to designate new units as needed.
Unit numerical or alphanumeric identifier	10-12	Actual unit designation, using alpha-numeric or numeric entry. Use zeros for less than three column entry. Examples: 024-24th Regiment 007-7th Armored Cavalry 477-4th Platoon 77th Rangers A23-Company A 23rd Battalion
Unit type	13-14	01-Infantry 02-Armor

Item	[illegible]	[illegible]
[illegible]		[illegible]
Unit affiliation	[illegible]	[illegible]
Date/time group: Day - cols 17-18 Month - cols 19-20 Year - (last digit) col 21 Time - cols 22-25	17-25	[illegible]
Time in transmission	26-28	[illegible]
Unit assignment	[illegible]	[illegible]

[illegible]

Item	Punch Card Columns	Coding Instructions and Remarks
Radio type	36-38	001-009: AN/PRC-type radios: 001-AN/PRC-10 002-AN/PRC-6 003-AN/PRC-25 021-029: HF man-pack tactical radios: 021-AN/GRC-9 022-AN/GRC-87 031-049: Vehicular VHF or HF tactical radios 051-059: Aircraft-mounted air-ground tactical radios 061-079: Naval tactical radios. Does not include "Army man-pack" radios used above naval craft 081-099: Available for coding additional field tactical radios 101: USOM rural security and police radios: 101-HT-1 102-TR-20 103-TR-5
AM/FM	39	1-AM 2-FM
Frequency in MHz or kHz	40-44	Numerical entry from right. Decimal point between columns 43-44 for MHz only. Enter kHz directly from right.
Modulation	45	1-Voice 2-Continuous wave 3-Single sideband
Antenna type	46	1-Short whip or tape 2-Long whip 3-Wire 4-RC-292 5-(et seq) Code additional types as required.
Distortion	47	0-None 1-Static

Item	Punch Card Columns	Coding Instructions and Remarks
Distortion (cont'd.)		2-Other [illegible]ion interference 3-Channel busy
Success of contact	48	1-Yes 2-No
Origin of communication	49	X-Base Y-Patrol Z-Another patrol W-Support arms or air T-Airborne relay U-Fixed relay V-Shipboard relay
Unit contacted	50	Same coding as column 49 above
Base station coordinates	55-62	Alphanumeric direct entry of UTM coordinates.
Weather at base	71	1-Clear 2-Cloudy 3-Rain
Topography at base	72	1-Flat 2-Valley 3-Hillside 4-Hilltop
Vegetation at base	73	1-Open 2-Brush 3-Trees
Corresponding line item	74	Is there a corresponding patrol line item? 1-Yes 2-No
Data sheet number: Sheet No. cols 75-78 Line No. cols 79-80	75-80	Enter sheet and line numbers from original field data sheets.

Blank columns on base station card are 29-34 and 51-54.

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U.S. AND ALLIED FORCES DATA CODING
PATROL CARD "A"

Item	Punch Card Columns	Coding Instructions and Remarks
Card serial number	1-5	2N (i.e., 2, 4, 6, 8...)
Card "A" identifier	6	Code "A" on all cards
Unit size	7	A-Squad B-Reinforced Squad C-Section D-Platoon E-Reinforced Platoon F-Company G-Reinforced Company H-Battalion I-Reinforced battalion J-(et seq) Add codes to designate new units as needed.
Unit type	8	A-Infantry B-Armor C-Artillery D-Mortar or heavy weapons E-Signal F-Cavalry G-Long Range Patrol or "Recondo" unit H-Junk Force Element I-Naval Patrol Craft J-LLDB K-CIDG L-RAG M-U.S. Special Forces N-(et seq) Add codes to designate new types of units as needed.
Company designator	9	Enter company alphanumeric designator.
Battalion designator	10-12	Enter battalion numeric designator with preceding zeros as required. For Special Forces units enter camp designator.

Item	Punch Card Columns	Coding Instructions and Remarks
Regiment designator	13-15	Enter regiment numeric designator with preceding zeros as required.
Brigade designator	16	Enter brigade numeric designator.
Division designator	17-19	Enter actual division numeric designator. Use preceding zeros as required.
Unit assignment	20	A-Assignment to unit listed in columns 9-19 B-Attached to unit not normally parent, designated in columns 23-32 C-Operating independently.
Unit affiliation	21	A-U.S. Army B-Korean C-Australian D-U.S. Marines E-U.S. Navy F-ARVN G-RF H-PF I-Vietnamese Rangers J-Vietnamese Airborne K-Vietnamese Marines L-Vietnamese Navy M-U.S. advisors to Vietnamese N-Paramilitary forces O-(et seq) Add codes to designate additional types of units as needed.
Unit mission	22	A-Reconnaissance B-Security C-Ambush D-Escort E-Search and Clear F-Pacification G-(et seq) Add codes as needed.
Assigned unit designation	23-32	Entry in this column only if there is a B in column 20. Identify unit as in columns 10-19.

Item	Punch Card Columns	Coding Instructions and Remarks
Patrol composition and size: Cols 33-35: No. of men Cols 36, 39, 42: Type of vehicle Cols 37-38; 40-41; 43-44: No. of vehicles by type indicated in previous column	33-44	Code columns 36, 39 and 42 as: A-1/4 ton or landrover B-3/4 ton or landrover C-2 1/2 ton D-5 ton E-APC F-Tank G-Armored car (wheeled) H-(et seq) Add codes as needed. Enter Z if no information furnished.
Range	45-49	Enter to nearest 10 meters.
Duration of patrol	50-53	Enter hours to nearest tenth (6 min.) decimal point between cols 52 and 53. Enter preceding zeros as required.
Contact with enemy	54	A-Yes B-No
Base station coordinates	55-62	Alphanumeric UTM entry. Cols 55 and 56 grid letter zone; cols 57 and 62 meter coordinates to 6 places. Use zeros in cols 59 and 62 if no information furnished.
Patrol station coordinates	63-70	Alphanumeric entry. Columns 63 and 64 grid zone; columns 65 and 70 UTM coordinates to 6 places.
Weather at patrol location	71	A-Clear B-Cloudy C-Rain
Topography at patrol location	72	A-Flat B-Valley C-Hillside D-Hilltop
Vegetation at patrol location	73	A-Open B-Brush C-Trees

Item	Punch Card Columns	Coding Instructions and Remarks
Corresponding line item	74	Is there a corresponding base station line? A-Yes B-No
Data sheet number	75-78	Enter sheet number from data sheet. Use preceding zeros.
Data line number	79-80	Enter line number from data sheet. Use preceding zeros.

PATROL CARD "B"

Item	Punch Card Columns	Coding Instructions and Remarks
Card serial number	1-5	2N (i.e., 2, 4, 6, 8...)
Patrol card B designator	6	Enter "B" on all cards
Type radio	7	A-AN/PRC-8, 9 or 10 B-AN/PRC-6 C-AN/PRC-25, AN/GRC-125 D-AN/GRC-3 thru 8 F-AN/GRC-9 or 87 G-AN/GRC-19 H-AN/GRC-26 I-AN/PRC-47 J-AN/PRC-64 K-AN/PRC-74 L-HT-1 M-TR-5 N-TR-20 O-AN/PRT-4 - AN/PRR-9 (et seq) Add additional codes as required.
Type antenna	8	A-Short whip or tape B-Long whip C-Wire D-RC-292 E-(et seq) Code additional types as required.
Type modulation	9	A-Voice B-Continuous wave

Item	Punch Card Columns	Coding Instructions and Remarks
Type modulation (cont'd.)		C-Single sideband D-Radio teletype
Frequency	10-14	Numerical entry from right decimal point between columns 12 and 13 for MHz only.
Distortion	15	A-None B-Static C-Other station interference D-Channel busy
Contact successful	16	A-Yes B-No
Origin of transmission	17	A-Base B-Patrol C-Another patrol D-Supporting arm E-Aircraft
Unit contacted	18	Same as column 17.
Type relay	19	A-AN/PRC-25 automatic retransmission B-AN/VRC-49 automatic retransmission C-AN/PRC-25 manual retransmission D-AN/VRC-46 manual retransmission E-Airborne automatic retransmission F-Airborne manual retransmission
Time in contact	20-22	Enter minutes to nearest tenth (i.e., 6 seconds) decimal point between columns 21 and 22.
Date/Time group Day - Cols: 23-24 Month - Cols: 25-26 Year - Col: 27 Time - Cols: 28-31	23-31	Day/Month/Year/Hour 01 11 66 1145

Item	Punch Card Columns	Coding Instructions and Remarks
Patrol composition and size	33-44	Same as columns 33-44, Patrol Card "A"
Range	45-49	Same as columns 45-49, Patrol Card "A"
Duration of patrol	50-53	Same as columns 50-53, Patrol Card "A"
Data sheet number	75-78	Same as columns 75-78, Patrol Card "A"
Data line number	79-80	Same as columns 79-80, Patrol Card "A"

Blank columns on patrol card "B" are 32 and 54-74.

U.S. AND ALLIED FORCES DATA CODING
BASE CARD

Item	Punch Card Columns	Coding Instructions and Remarks
Card Serial number	1-5	2N-1; example 1, 3, 5, 7...
Unit size	7	A-Squad B-Reinforced squad C-Section D-Platoon E-Reinforced platoon F-Company G-Reinforced company H-Battalion I-Reinforced battalion J-(et seq) Add codes to designate new units as needed.
Unit type	8	A-Infantry B-Armor C-Artillery D-Mortar or heavy weapons E-Signal F-Cavalry G-Long Range Patrol or "Recondo" unit H-Junk Force Element I-Naval Patrol Craft J-LLDG K-CIDG L-RAG M-U.S. Special Forces N-(et seq) Add codes to designate new types of units as needed.
Company designator	9	Enter company alphanumeric designator.
Battalion designator	10-12	Enter battalion numeric designator with preceding zeros as required. For Special Forces units enter camp designator.

Item	Punch Card Columns	Coding Instructions and Remarks
Regiment designator	13-15	Enter regiment numeric designator with preceding zeros as required.
Brigade designator	16	Enter brigade numeric designator.
Division designator	17-19	Enter actual division numeric designator. Use preceding zeros as required.
Unit assignment	20	A-Assignment to unit listed in columns 9-19 B-Attached to unit not normally parent, designated in columns 23-32 on Patrol Card C-Operating independently
Unit affiliation	6	A-U.S. Army B-Australian C-Korean D-U.S. Marines E-U.S. Navy F-ARVN G-RF H-PF I-Vietnamese Rangers J-Vietnamese Airborne K-Vietnamese Marines L-Vietnamese Navy M-U.S. advisors to Vietnamese N-Paramilitary forces O-(et seq) Add codes to designate additional types of units as needed.
Radio type	21	A-AN/PRC-8, 9 or 10 B-AN/PRC-6 C-AN/PRC-25, AN/GRC-125 D-AN/GRC-3 thru 8 E-AN/VRC-43 thru 49 F-AN/GRC-9 or 87 G-AN/GRC-19 H-AN/GRC-26 I-AN/PRC-47

Item	Punch Card Columns	Coding Instructions and Remarks
Radio type (cont'd.)		J-AN/PRC-64 K-AN/PRC-74 L-HT-1 M-TR-5 N-TR-20 O-AN/PRT-4 AN/PRR-9 (et seq) Add additional codes as required.
Type antenna	22	A-Short whip or tape B-Long whip C-Wire D-RC-292 E-(et seq) Code additional types as required.
Type modulation	23	A-Voice B-Continuous wave C-Single sideband D-Radio teletype
Frequency	24-28	Numerical entry from right decimal point between columns 26 and 27 for MHz only.
Distortion	29	A-None B-Static C-Other station interference D-Channel busy
Contact successful	30	A-Yes B-No
Origin of transmission	31	A-Base B-Patrol C-Another patrol D-Supporting arm E-Aircraft
Unit contacted	32	Same as column 31.
Time in contact	33-35	Enter minutes to nearest tenth (i.e., 6 seconds) decimal point between columns 34 and 35.

Item	Punch Card Columns	Coding Instructions and Remarks
Date/Time group Day - Cols: 23-24 Month - Cols: 25-26 Year - Col: 27 Time - Cols: 28-31	36-44	Day/Month/Year/Hours 01 11 66 1145
Range	45-49	Enter to nearest 10 meters.
Base station coordinates	55-62	Alphanumeric UTM entry. Cols 55 and 56 grid letter zone; cols 57-62 meter coordinates to 6 places. Use zeros in columns 59 and 62 if no information furnished.
Patrol station coordinates	63-70	Alphanumeric entry. Columns 63 and 64 grid zone; columns 65-70 UTM coordinates to 6 places.
Weather base location	71	A-Clear B-Cloudy C-Rain
Topography at base station	72	A-Flat B-Valley C-Hillside D-Hilltop
Vegetation at base location	73	A-Open B-Brush C-Trees
Corresponding line item	74	Is there a corresponding base station line item? A-Yes B-No
Data sheet number	75-78	Enter sheet number from data sheet. Use preceding zeros.
Data line number	79-80	Enter line number from data sheet. Use preceding zeros.

Blank columns on base card are 50 thru 54.

CODING OF PHYSIOGRAPHIC DATA

Note: Symbols shown in this coding are as follows:

(*) Transfer mechanically from basic data cards, no coding necessary.

(*T) Transfer mechanically from topographic data card, no coding necessary.

WAVE PATH PHYSIOGRAPHY
TOPOGRAPHIC DATA CARD

Item	Punch Card Columns	Coding Instructions and Remarks
Line item serial and unit designation	1-7*	Transfer directly from basic data card, either patrol or base station.
Base station coordinates	8-15*	Transfer by reproducing punch from cols 55-62 in basic data card.
Patrol coordinates	16-23*	Transfer by reproducing punch from cols 63-70 in basic data card.
Range	24-28	Manual computation.
Map sheet number	29-34	Enter serial number of appropriate AMS L710, 1:50,000 maps as follows: If entire communication is contained on one map sheet, enter "1". Column 29: Number of map sheets covered. If entire communication is contained on one map sheet, enter "1". If wave path covers more than one map sheet, enter the number of sheets crossed by the transmission. Columns 30-33: Enter serial of prime map sheet. Column 34: Enter subsheet number, translating I, II, III, IV to arabic equivalents.
Success of contact	35*	Transfer from column 48 basic patrol or base card.
Presence of terrain mask	36	Establish hasty profile along wave path. Presence or absence of terrain mask or masks are coded as follows: 1-Mask present (refer to mask analysis card) 2-No masks present

Item	Punch Card Columns	Coding Instructions and Remarks
Topographic wave path description	Fields 37-42 43-48 49-54 55-60 61-66 67-72	First two columns (37, 38, 43, 44, 49, 50 et seq) percent of wave path described. Next column (39 et seq) nature of topography in sector described: 1-Plane 2-Undulating 3-Rolling 4-Rough 5-Very rough Next column (40 et seq) if wave path crosses water, code hydrographic features as follows: 1-Lake 2-River or major canal 3-Innundated paddy lands (check seasonal flooding with date of communication) 4-Tidal swamp 5-Fresh water swamp 6-Tidal inlet or open ocean 7-Small lake or pond Column 41 (et seq) salinity/acidity of water body if applicable: 0-Not applicable 1-Fresh 2-Acidic (evaporative fresh) 3-Brackish 4-Saline Column 42 (et seq) significant culture feature if applicable: 0-None 1-Large urban area (concrete buildings) 2-Town or large military camp 3-Village or small military camp 4-Hamlet or outpost 5-Major steel or concrete bridge 6-Major road 7-Railway 8-Powerline 9-Airfield

Item	Punch Card Columns	Coding Instructions and Remarks
Physiographic province and region	73-74	Code from map supplied. Col 73 province; col 74 region.
Topography at base station	75	Transfer from base card, col 72.
Topography at current patrol location	76	Transfer from patrol card, col 72.
Weather at base station	77	Transfer from base card, col 73.
Weather at current patrol location	78	Transfer from patrol card, col 73.

Blank columns on topographic data card are 79-80

WAVE PATH PHYSIOGRAPHY
TERRAIN MASKING ANALYSIS

Item	Punch Card Columns	Coding Instructions and Remarks
Line item designation serial and location data	1-28*T	Transfer from topographic card by reproducing punch.
Map sheet reference data	29-33*T	Transfer from topographic card by reproducing punch.
Distance from base station to nearest mask (m_b)	34-38	Measure in meters from topographic map.
Relative height of (m_b)	39-42	Establish hasty profile, measure height of (m_b) above profile base line.
Surface configuration of (m_b)	43	Code surface conditions of (m_b) as follows: 1-Smooth 2-Undulating 3-Rolling 4-Rough 5-Very rough
Vegetation density of (m_b)	44	Code vegetation of (m_b) by inspection of topographic map as follows: 1-Barren or grassland 2-Sparse brush mixed with barren or grassland 3-Brush 4-Sparse trees 5-Mixed trees and brush 6-Moderately dense trees 7-Dense trees
Distance from patrol station to nearest mask (m_p)	45-49	Measure in meters from topographic map.
Relative height of (m_p)	50-53	Code as instructions for cols 39-42.

Item	Punch Card Columns	Coding Instructions and Remarks
Surface configuration of (m_p)	54	Code as instructions for col 43.
Vegetation density of (m_p)	55	Code as instructions for col 44.
Distance from base station of highest mask on wave path (m_{max})	56-60	Measure in meters from topographic map.
Relative height of (m_{max})	61-64	Code as instructions for cols 39-42.
Surface configuration of (m_{max})	65	Code as instructions for col 43.
Vegetation density of (m_{max})	66	Code as instructions for col 44.

Blank columns on terrain masking analysis are 67-80.

WAVE PATH PHYSIOGRAPHY
VEGETATION DATA CARD

Item	Punch Card Columns	Coding Instructions and Remarks
Line item designation and serial	1-7*	Transfer directly from basic data card, patrol or base. Same field as in basic data card.
Base station coordinates	8-15*	This information contained in base station cards. Transfer from cols 55-62.
Patrol coordinates	16-23*	Transfer from cols 63-70 on basic data card. Data is contained in all patrol cards and on most base cards.
Range	24-28*T	Transfer from topographic card. Same fields.
Vegetation at base station	29*	Transfer from base card, col 73.
Vegetation at patrol location	30*	Transfer from patrol card, col 73.
Vegetation along wave path: Fields: 31-36 37-42 43-48 49-54 55-60 61-66	31-66	In each field code as follows: Columns 31-32: percentage of wave path described. Columns 33-34: type of vegetation as follows: 00-Barren (primarily beach and dune sands but may include upland clearings recently logged or burned over) 01-Builtup area 02-Open water 10-Rice, undifferentiated 11-Rice, seedlings 12-Rice, mature 13-Rice, harvested 14-Rice and fresh water swamp mix

Item	Punch Card Columns	Coding Instructions and Remarks
Vegetation along wave path (cont'd.)		20-Grassland, undifferentiated 21-Grassland, high grass 22-Grassland, low grass 23-Grassland, burned over 24-Grassland, inland marsh 25-Grassland, coastal marsh 26-Bamboo (where separately differentiated on vegetation maps) 30-Trees (undifferentiated species and types) 31-Trees (primary evergreen jungle) 32-Trees, secondary evergreen jungle 33-Trees, primary and secondary evergreen jungle mix 34-Trees, primary and semiever-green (mixed with deciduous) jungle 35-Trees, secondary semievergreen jungle 36-Trees, mixed primary and secon-dary semievergreen jungle 37-Trees, primary deciduous jungle 38-Trees, secondary deciduous jungle 39-Trees, primary and secondary deciduous jungle mix 40-Trees, conifers and casuarina 41-Trees, mangrove 42-Trees, salt and brackish water tolerant (cajaput, nipa, etc.) 43-Canal and stream bank trees - unspecified (Additional "40" series held for further tree categorization) 50-Swamp, undifferentiated vege-tation 51-Swamp, deltaic or sea level 52-Swamp, inland, lowland 53-Swamp, inland, upland

Item	Punch Card Columns	Coding Instructions and Remarks
Vegetation along wave path (cont'd.)		54-Swamp, coastal (typically coded as "41" mangrove but may have other vegetation characteristics) (Additional "50" series held for further swamp categorization) 60-Brush, undifferentiated 61-Brush, low 62-Brush, high 63-Brush, mixed heights 64-Brush, tree mix 65-Brush, grassland mix (Additional "60" series held for further brush vegetation categorization) 70-Plantation, low bush crops (tea) 71-Plantation, low tree crops (banana, young rubber) 72-Plantation, mature rubber 73-Plantation, coconut 74-Plantation, mixed tree and bush crops (coffee) 75-Dry crops, undifferentiated 76-Dry crops (field grains) 77-Dry crops (vegetables, manioc) Column 35: density of vegetation as follows: 1-Open, no vegetation, dry crops or ricelands 2-Sparse 3-Moderate (shown on L7014 as "clear forest") 4-Heavy 5-Dense 6-Very dense 7-Mixed 8-Stream bank Column 36: presence of clearings in area described: 1-No clearings 2-Scattered, abandoned, overgrown 3-Scattered, active agriculture, burning or logging in progress 4-Scattered settlements or hamlets 5-Many abandoned, overgrown

Item	Punch Card Columns	Coding Instructions and Remarks
Vegetation along wave path (cont'd.)		6-Many active agriculture, burning or logging in progress 7-Open water 8-Builtup area
Vegetation masks along path examined	67	1-None 2-Canal or stream bank tree lines 3-Road tree lines 4-Village tree lines 5-Combination
Number of vegetation masks along wave path	68	1-None 2-1 3-2-5 4-6-10 5-10 or more
Summary wave path vegetation density	69	Summary density of entire wave path vegetation. List as col 35 if feasible.
Summary wave path vegetation type	70-71	Code as cols 33-34 if feasible.
Physiographic province and region	72-73*T	Transfer from topographic card.
Map reference	74-78*T	Transfer from topographic card.

Blank columns on vegetation data card are 79-80

WAVE PATH PHYSIOGRAPHY
WAVE PATH SURFACE AND SUBSURFACE MATERIALS DATA CARD

Item	Punch Card Columns	Coding Instructions and Remarks
Line item designation and serial	1-7*	Transfer directly from basic data card, either base or patrol series. Same field as in basic data card.
Base station coordinates	9-15*	This information contained in base station cards. Transfer from cols 55-62 in basic data card.
Patrol coordinates	16-23*	Data contained on all patrol and on most base cards. Transfer from cols 63-70 on basic data card.
Range	24-28*T	No coding needed - transfer from topographic data card. Same field.
Soil conditions along wave path Fields: 29-34 35-40 41-46 47-52 53-58	29-57	In each field code as follows: Columns 29-30: percent of wave path described. Columns 31-32: soil type, coded from FAO soils maps: 01-Alluvial soils 02-Saline alluvial soils 03-Acid alluvial soils 04-Very acid alluvial soils 05-Brown alluvial soils 06-Regosols on young sand 07-Regosols on red sand 08-Regurs and latosols 09-Non-calcic brown soils on acid rocks 10-Non-calcic brown soils on old alluvium 11-Sandy podzolic soils 12-Red and yellow podzolic soils on acid rocks 13-Red and yellow podzolic soils on old alluvium 14-Gray podzolic soils

Item	Punch Card Columns	Coding Instructions and Remarks
Soil conditions along wave path (cont'd.)		15-Low humic gley soils 16-Podzolic soils and regurs 17-Podzolic soils and alluvial soils 18-Mountainous soils 19-Reddish brown latosols 20-Red latosols 21-Earthy red latosols 22-Shallow latosols 23-Reddish brown and red latosols 24-Reddish brown and compact brown latosols 25-Peat and muck soils Column 33: state of saturation: 1-Dry 2-Moist 3-Damp 4-Wet 5-Saturated Column 34: salinity and/or acidity: 1-Non-saline 2-Saline 3-Low Ph 4-High Ph
Rock types along wave path Fields: 59-63 64-68 69-73 74-78	59-76	In each field code as follows: Columns 59-60: percent of wave path described. Columns 61-62: type of rock, code from NGS 1:500, 000 geological map Column 63: occurrence: 1-Outcrop 2-Subsurface
Physiographic province and region	79-80	Column 79: 1-Delta 2-Terraces 3-High Plateaus 4-Interior highlands 5-Coastal hills Column 80: Region a, b, c, etc., as appropriate from map.

APPENDIX B

Appendix B to the third Semiannual Report of the "Communications Research and Development Data Collection Program in the Republic of Vietnam" contains selected summaries from interviews with U.S. and FWF units conducted by team members. It is not meant to stand alone, but to be an integral part of the basic report. It is published separately so that the basic report may be unclassified.

The U.S. and FWF units visited by the study group have been shown in Table 9 and are further presented by location in Figure B-1 in this appendix.

APPENDIX C

TONAL CHARACTERISTICS OF THE VIETNAMESE LANGUAGE

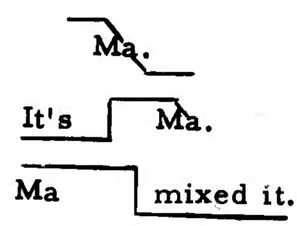
The following paragraphs adapted from Speak Vietnamese by Professor Nguyen Dinh Hoa of the University of Saigon, (Saigon: Department of National Education, 1963), are presented herein in support of conclusions 5 and 6 of the dialect study in which it can be seen that tonal fluctuations in Vietnamese (either northern, central or southern dialects) are capable of producing changes in word meaning and therefore intelligibility.

. . . .

TONES

Native speakers of English use different pitch levels: a Vietnamese hearer, or any other hearer, will notice that there is a kind of tune to what you say. This sing-song contour is meaningful. When you say « ma » (meaning "mother") for instance, that word may be said with different tunes. Your voice may start at a high level, then fall all the way to the lowest level of your (normal) speaking voice range: when you respond, « It's Mother » to a question by, say, your brother or sister who wants to know who mixed that nice salad, that's what you say -- « Ma » . Or you may start rather high, then drop your voice a little, as when you call your mother when she is in the next room. On some other occasion, when you want to know if someone is talking about your mother, you'll likely say « Ma ? » , letting your voice start quite high on the scale and rise gradually to the top of it.

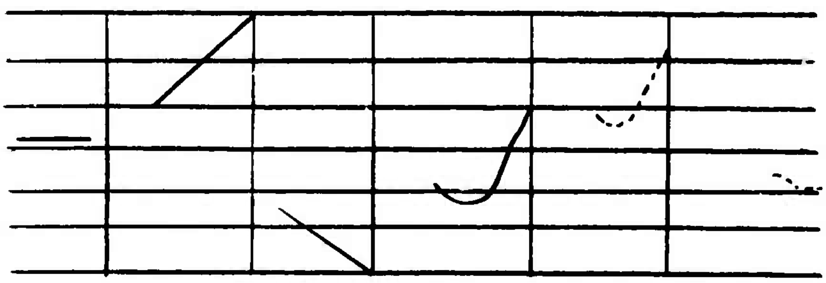
In all three cases, the word ma means the same thing, and the tune to which it is sung is something extra and has been called "intonation." Intonation may extend over a whole sentence, that is, you will recognize the same tune going with the words « It's Ma. » or «Ma mixed it.» as you did the first example above (« Ma »). The intonation curve can be drawn as follows:



Vietnamese differs from your mother tongue since each syllable ma is as much a part of it as the consonant m and the vowel a. The syllable ma may be said in six different tunes and mean six different things: the six resulting syllables are as different as ma, moo, me, and maw in English. The tunes, each of which is an integral part of a Vietnamese syllable, are called "tones."

Here is a brief description of the tones, in the frequently followed order: ma, má, mà, mả, mã, mạ.

The vertical lines represent the range of the variation of pitch: it is divided into six equal intervals with seven points, number 1 (lowest level) to 7 (highest level).



(1) Mid level tone (no mark used): the voice begins at about the middle of the normal speaking voice range (pitch level 4) and remains at approximately the same level except before a pause, when it falls slightly.

ma	'ghost'	ba	'three'
tôi	'I'	năm	'five'
hai	'two'	ai	'who'

(2) High rising tone (in Vietnam sắc 'sharp') (indicated by an acute accent over the main vowel): the voice starts high (about level 5) and rises sharply (to 7).

má	'cheek'	bá	'to hug'
tối	'dark'	nắm	'fist'
hái	'to pick (fruit)'	ái	'ouch'

(3) Low falling tone (in Vietnamese huyền 'hanging') (indicated by a grave accent over the main vowel): the voice starts at a fairly low level (3 or 2) and falls gradually to the lowest level of the normal speaking voice range.

mà	'but'	bà	'grandmother'
tồi	'mediocre'	nằm	'to lie down'
hài	'shoe'	ài	(no meaning)

(4) Low rising tone (in Vietnamese hỏi 'questioning') (indicated by the upper part of a question mark ? over the main vowel): the voice starts quite low, dips slightly, and then rises rather slowly to a somewhat higher level.

mả	'tomb'	bả	'bane'
tổi	(no meaning)	nẳm	(no meaning)
hải	'marinus'	ải	'frontier post'

(5) High broken tone (in Vietnamese ngã 'falling') (indicated by a tilde ~ over the main vowel): the voice starts just a little above the middle of the normal speaking voice range, dips down a very little, then rises abruptly; during the rise the throat is constricted so that the voice is interrupted or is given a strained or creaky quality; the syllable usually terminates with full voice near the top of the voice range.

mã	'equus'	bã	'residue, dregs'
tỗi	(no meaning)	nẵm	(no meaning)
hãi	'afraid'	ãi	(no meaning)

(6) Low broken tone (in Vietnamese, nặng 'heavy') (indicated by a dot beneath the main vowel): the voice starts a little below the middle of the voice range, falls immediately and very abruptly to a lower level where it is cut off by a constriction called glottal stop. Occasionally, in slow careful speech, or when the syllable is especially emphasized, the voice is restored at the end of the syllable, as in the high broken tone.

mạ	'rice seedling'	bạ	'haphazardly'
tội	'sin, crime'	nặm	(no meaning)
hại	'harm'	ại	(no meaning)

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13. ABSTRACT

This paper summarizes the third six-month period of research by the Booz Allen Southeast Asia Operations field team in support of the Advanced Research Projects Agency small unit tactical communications project entitled, "Communications Research and Development Data Collection Program in the Republic of Vietnam." It presents an initial analysis of Vietnamese patrol and base practices and discusses the on-going program of communications data collection among U.S. and Free World Forces units. It describes communications practices in use by some of these units and reports findings to date in the area of radio wave path physiography, radio frequency, and dialect analyses. It recommends the use of directional-type antennas for tactical very high frequency and describes a simple, lightweight concept which could be used by tactical units.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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Communications						
Small Tactical Unit						
Directional antenna						
Wave path physiography						
Dialect						